THE FIELDS OF GREAT BRITAIN

HUGH CLEMENTS

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THE

FIELDS OF GREAT BRITAIN

A Text-Book of Agriculture

ADAPTED TO THE SYLLABUS OF THE SCIENCE AND ART DEPARTMENT, SOUTH KENSINGTON

FOR ELEMENTARY AND ADVANCED STUDENTS

CONTAINING

EXTRA SUBJECTS OF INTEREST AND UTILITY TO AGRICULTURISTS AND FARMERS

BY

HUGH CLEMENTS

BOARD OF TRADE

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AT THE SOUTH LONDON TRAINING COLLEGE, BLACKFRIARS

WITH AN INTRODUCTION BY

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INTRODUCTION.

In the hard school of adversity landlords and tenants are now alike being educated (and both had much to learn) in the present true position of agriculture. The lessons of the years 1875 to 1879 inclusive have been painful to get by heart—they have taught many landowners to yield up a fourth of their income, and compelled many farmers to give up their homes; whilst—hardest of all—owners and occupiers at the same time have had to relinquish hope that, after the passing of the time of trial, the old prosperity might return. Let the landlord accept the truth that the soil of England is not, and will not, be worth its old value by 30 per cent.; let the farm occupier acknowledge that he must work harder for less and more uncertain profits than hitherto; let both agree that fresh conditions of renting and fresh methods of cultivating the land are necessary in the new order of things, and then neither will see

reason to despair. The landlord's land will not go out of cultivation; it will still remain probably at quite two-thirds of its recent value, and confer honour and position on its possessor; and the farmer may still hope, spite of foreign competition in grain and the vicissitudes of the English seasons, to get also his two-thirds of a former income out of the land. Granted that landlords and farmers must now be accounted poorer men than they were ten years ago, what then? May not they, and with them English agriculture, still prosper? Riches are but comparative possessions, and a class that loses one-third of its income does not lose thereby its honourable position in the nation. English agriculture, if less profitable than formerly, may still proudly keep its place at the head of European husbandry, nor is it likely to lose its relative position in respect to other classes. All classes are being shifted to a lower level as regards income. The world demands more work and time for money than was accepted in the early half of the present decade. The manufacturer as well as the agriculturist, the artisan as well as the farm labourer, have to be content with three-quarters of the whole loaf they once had.

Luxury has to be left behind perhaps, and thrift, frugality, and simplicity in living have to be substituted; but such a change does not take the sunshine out of life, and it may be hoped and expected that British agriculture, taking a new start after its great trials, may yet afford comfort, health, and independence to the useful and honourable classes who cultivate the land and rear the nation's flocks and herds.

Production, competition, methods of husbandry, freedom of cultivation and sale of produce, arable land, grazing, pasture, orchards, hops, manures, rent, workmen's wages, capital invested and local taxation, are the several subjects on which the agricultural mind of the country is now exercised, and these in due order make up the farmer's education, to which, as a pocket companion, the following pages will be found a useful text-book.

But the A B C of this education is for landlord and farmer alike to accept their new position in agriculture. They must agree to eat contentedly two-thirds of a loaf, although they should strive to make that two-thirds as sweet, heavy, and good as the arts of husbandry and the climate of the

country will allow. Can they accomplish much in this direction? Probably not enough to make a big loaf again, but quite enough to reward all prudent effort.

First, as regards the production of grain, it is not likely a much better yield per acre can be made than is at present grown —that is, *not on the same areas.* But whilst Kent grows nearly 34 bushels per acre of wheat, and parts of Yorkshire, all Lancashire, Lincolnshire, Huntingdonshire, Northamptonshire, and Cambridgeshire exceed 32 bushels per acre, it should be the rule of the English farmer to plant wheat only on wheat land, where 4 qrs. per acre should be the minimum yield of a fair season on every sound, well-cultivated acre of land in good heart. This rule would reduce the breadth of the wheat area considerably, and wisely divert to other uses the soil that, either from its constituents, climate, slope, aspect, or level, does not pay to grow wheat, but which, in times past, after European wars and pre-free-trade days, paid the farmer for labour and capital. America had not then an annual wheat surplus of 20,000,000 qrs.

As to what purposes the disused artificial wheat land should be put must be left to

practice. At present we know that all the malting barley we can grow, all the feeding oats that can be raised are wanted for home use, and to form a rotation with root crops. In respect to the growth of grass and the plantation of woods, hops, and fruit trees, such cultivation of the land does invite the landowner's and farmer's attention, and promises fairly profitable results. There are few sandy wastes or boggy levels that, planted with trees, would not, over thirty years, yield the owner of the ground a rent of £1 per acre per annum, where now the farmer cannot pay him 5s. per acre. On this subject the vulgar outcry against making corn farms or sheep farms into deer preserves or forests, as being anti-patriotic and opposed to the interests of the working-classes (robbing a poor man of his right to labour, of his bread, &c., &c.), must be at once silenced and dismissed. If, on the one hand, the majority of a nation, in order to buy cheap bread and meat, support, towards that end, the free importation of wheat and cattle, it is only logical and *English in its fairness* that the landowner and farmer (unable to meet foreign competition) should be privileged to do their best, and with all freedom,

by devoting the land to the purpose which pays best. Whether the acres produce potatoes or partridges, venison and sport or mutton and many shepherds, is no longer the affair of those who have adopted the political motto of "buying wherever you can in the cheapest market." The land, therefore, must in the future be devoted to whatever purpose gives the best money result, and a simple naturalist and husbandman making a survey of Great Britain and Ireland would have little difficulty in deciding how, in most cases, their surfaces should be cultivated. The climate, the rainfall, much of the soil, call out together in chorus—" Here grass is king," and in more detail add, here tracks of woodlands should clothe the hill sides and look down upon the green pastures of the meadows. Fruit trees and hops, roots, osier beds, parks and gardens should abound, with here and there corn, like patches of sunlight in the landscape, to break the surface of the country. But the breadth must be of grass, must be of bullock pastures, hay meadows, turf downs, animated with horses, herds and flocks, with corners for ground-game farming as a source of profit, rabbit warrens and poultry runs.

It is in this direction of grass-growing that the greatest hopefulness is shown. Until lately taught by our agricultural societies, by our geological and chemical investigations as to soil and seed, and aided by the skilful trade shrewdness of our great seedsmen, grass was never really farmed—*grass was simply allowed to grow*, regarded as a natural covering of the soil, and that *all was good alike*. But pastoral husbandry in a few favoured districts—in dairy farms—called attention to the goodness of milk, the richness of butter, produced off some special pastures, and year by year grass land and grass farming has become more and more a study. Now it is the paramount interest of the landowning class of the country, and probably another century may see the numbers of farmers and graziers reversed, and well-farmed grass land yield fully one-third more as an average crop than at present.

There is really nothing alarming in the prospect that England, becoming more and more beautiful, park-like, and pastoral, should have to buy more wheat from abroad than at present. Because we do not grow tea, nor sugar, nor rice, nor oranges, do we go short of these useful articles? Their cheapness is our boast. And since we already import 60 to 70 per

cent. of our breadstuffs in bad seasons with ease, the necessity of doing so in all years need not be a subject of alarm to a nation that literally carries the world in its ships.

Let landowners and farmers anxious about their future—about the position of agriculture—look to the census that next year will tell how many are we! Let them make a census of the parks, the seats, the mansions, the dwelling houses, the workshops that make up this England; and again let them look to their income-tax papers, and form conclusions of the good, hard money that year by year the nation has to spend, and then form their conclusion whether any fertile land in this populous country will ever go out of cultivation, or whether it will not always pay the owner a moderate rent, and yield to the farmer and his workmen a reasonable income and wages. I say yes; but that landlord and farmer must consent to be born again, and adapt themselves to the new agricultural world in which they live. Such new landlord and new farmer have still a goodly heritage in British agriculture.

H. Kains-Jackson.

13A Salisbury Square, E.C.,
November 1880.

PREFACE.

I WAS induced to prepare this little work, which appeared in the *Farmer*, in order to supply a want felt by teachers, as well as students of Agricultural Classes connected with the Science and Art Department, of a text-book dealing with the advanced portion of the syllabus, and also to present the student and the farmer with at least a portion of the experience gained at a farm and Agricultural College, from the practical work and instruction of one of the greatest agriculturists of the day.

I have dealt with the elementary and advanced stages as a whole, blending them together systematically, so that it is hoped that the student will find all the information he may

require to pass the examination successfully. I have, in the chapters on Food and in other interesting matters, gone beyond the requirements of the Science and Art Department, while in others I hope I have not transgressed in the contrary direction. However, in dealing with a subject requiring such a vast amount of varied knowledge and experience, I must crave the reader's kind indulgence.

The subject of agriculture is now attracting a considerable amount of attention, due to a succession of bad harvests; so much so that a Royal Commission has been appointed to make extensive enquiries into the condition of agricultural matters in this as well as other countries, and it is to be hoped that the results of their investigations will lead to valuable recommendations, which, when acted upon, will tend to promote the farming interests of this country. Great advances have been made within the last half century in every branch of agriculture, both practical and theoretical; but the great drawback has been that farmers generally have lagged behind, not keeping their

practice up to the level of scientific experience. However, it is to be hoped that the spirit of improvement that is abroad will induce them to pay more attention to the principles upon which farming is based. The Science and Art Department now teach those principles over the length and breadth of the land, at a trifling charge, to all who care to learn them. It is therefore most desirable that landlords, gentlemen farmers, tenant farmers, bailiffs, land stewards, and others, should encourage all youths in any way connected with farming to attend the classes on Agriculture in connection with South Kensington, or send their sons to the Royal Agricultural College and other schools where the practice of farming, based upon scientific principles, is demonstrated.

There is no doubt but that if farmers thoroughly understood their business, that very much larger crops and more flesh and milk would be produced than is now done. In fact, in some parts of the country, *e.g.*, the Eastern Counties, the Lothians, &c., farming has attained a considerable degree of perfection

while in other parts it is still in a comparatively primitive condition. Although our best farmers have attained a certain standard, still the acme of perfection is far off, and can only be approximately realized by the arduous exertions of all concerned in the progress of agriculture and the welfare of England.

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THE

FIELDS OF GREAT BRITAIN.

CHAPTER I.

SOILS.

THE soil that we find in this and other countries has been formed by the disintegration of the rocks composing the earth's crust. The primitive crystalline rocks form the basis from which all other rocks and soils have been formed. The disintegration of rocks to form soils has been a very slow process, considering that to form a layer of soil one-twelfth of an inch deep would require 1,000 years, as calculated by Liebig, the great German chemist, who assiduously, patiently, and perseveringly investigated the constitution of soils and plants.

It will be observed that rocks become

covered with a minute vegetation, the decay of which furnishes food for future plants, and so on from time to time there is a gradual but slow increase of soil. Now, considering the depth of the soil and subsoil in many districts, some idea may be formed of the time that has elapsed since the rocks first began to disintegrate. This disintegration is effected by air and moisture, the atmosphere containing oxygen and carbonic anhydride, which act chemically. The oxygen increases the degree of oxidization : for instance it converts the ferrous oxide in rocks into the ferric, and assists the progress of decay in many other ways that will be referred to in another place.

Carbonic anhydride has an affinity for potassium and sodium, chemically uniting with them, and forming carbonates that are soluble in water, rendering the crystalline rocks such as granite friable and easily split up. Again, carbonic anhydride, when present in water that oozes through rocks, dissolves calcic carbonate, thus disintegrating rocks in which this compound may exist.

And water itself disintegrates rocks by its grinding action in the form of glaciers, which we can see at work, at the present time, in Switzerland, and of which we have faithful evidence in the mountains of Wales. Water also, when it permeates rocks or gains admission to cavities in them expands suddenly at

certain temperatures with such a resistless force that rocks are split up.

Rocks, over which water is continually passing, become water-worn, their dimensions being gradually reduced, and their irregularities removed. Again, fragments of rocks, over which water passes in mountain torrents, streams, rivers, or on the sea-shore, become rounded in form by a continual rubbing of one fragment against the other, and the fine particles removed by this action form mud or sand, according to the nature of the fragments.

Volcanic action has formed fertile lava soils in countries that have been subjected to volcanic eruptions. The decay of grasses, mosses, lichens, &c., has assisted in forming soils containing organic matter. As soils have been formed in a great measure from the disintegration of rocks, especially the igneous or crystalline, it is necessary to know something about them. They have been produced from materials fused by heat. In position they lie under all other rocks, and come from below by breaking through those more recently formed. These rocks are vitreous when they have been cooled quickly, granular containing crystals when more slowly cooled, and vesicular when they have been expanded by the contained gases on cooling. These rocks may be conveniently divided into three classes: (1) the Granitic; (2) the Trappean; (3) the Volcanic. The granitic

are generally associated with the Palæozoic strata, but occasionally are found in contiguity with secondary and even tertiary rocks. The granitic rocks contain a large amount of silica, which forms quartz, and is also one of the principal constituents of felspar, mica, and hornblende occurring in them.

The trappean rocks are found with Palæozoic or secondary strata, and are composed of felspar and hornblende, and vary according to the predominance of either of these minerals.

The volcanic belonging to the tertiary strata, are therefore the most recent igneous rocks, and have a similar composition to the trappean, containing augite, a mineral closely related to hornblende.

The metamorphic were originally deposited as stratified rocks. By pressure, cementing fluids, &c., mud and clay were converted into shale, and sand into sandstone, &c. These rocks have been, by heat and intense molecular action, converted into clayslate, mica schist, gneiss, marble, &c. They have been formed contemporaneously with the stratified rocks from the Laurentian or lowest upwards to the tertiary. In these rocks silica forms from 60 to 70 per cent., and the remaining 30 or 40 per cent. is made up of alumina, lime, potash, soda magnesia, iron, &c. In fact, their constitution is similar to that of clay or sandstone.

The aqueous, or stratified, or sedimentary

rocks have been deposited in layers at the bottom of oceans, seas, lakes, or the beds of rivers. Seas, rivers, glaciers, and icebergs have contributed to their formation. Gypsum, rock salt, and calcareous tufa have been formed by precipitation from the fluid containing them. Limestone and chalk are of animal, and coal of vegetable origin. The stratified rocks consist principally of sand, clay, lime, saline, and carbonaceous matter.

The igneous rocks, including the granitic, basaltic, and volcanic, produce naturally fertile soils although they are not often thoroughly disintegrated. The metamorphic rocks yield a poor soil.

The Laurentian, Cambrian, and Silurian are almost equally barren. But the old red sandstone, marl beds, and limestone of the Devonian furnish fertile soils, such as those of Monmouth, Hereford, Strathmore, and Moray, other conditions being favourable, but under unfavourable circumstances they yield barren moors and heaths.

The carboniferous mountain limestone also yields a fertile soil, and so does the new red sandstone of the Permian and triassic groups.

The Lias, the Oolitic and the Wealden yield clay soils that are often dense and untractable, but of considerable fertility.

The cretaceous soils exhibit various degrees of fertility, but as a rule they are too porous.

When the clay or sand and the chalk are mixed naturally in due proportions these soils are very fertile. The tertiary soils are sometimes very fertile, and sometimes almost barren.

The newer formations are found to the south-east of England, and the older successfully appear until we come to the flag-stones and slates of Wales, and the gneiss and granite of the Highlands. Soils may be divided into two classes—viz. those that have been formed from the underlying rocks, and those that have not. The former may be called sedentary soils, partaking of the nature of the underlying rocks or subsoil, while the latter are termed transported, being formed from the disintegrated particles of rocks found at considerable distances from the place of deposition. Those transported soils produced by glacier action or winds are termed drift soils, and those formed along the banks, and at the mouths of rivers by the flowing water, tides, and floods, are called alluvial soils. The boulder clay drift has been formed by glacial ocean action, and extends southward in this country nearly to London. The clay itself has been formed from the local rocks by glacial action, but the boulders varying in size from large masses of rocks to small pebbles were transported from remote regions by the same glacial action. The boulder clay is well represented in Eastern and Central England, and in the vicinity of Edinburgh.

In county Wexford, Cornwall, and Nairnshire accumulations of sand are being formed by the action of winds drifting it over land that was previously cultivated. The prevailing westerly winds cause these sand accumulations to move slowly to the east. The wind rolls or lifts the sand up the western aspect of these mounds until the summit is reached, when it falls over, forming an incline to the east equal to the angle of repose for sand. In Nairnshire the sand drift moves eastward at the rate of upwards of 50 feet annually. The alluvial soil formed along the banks and at the mouths of rivers is generally very fertile. This soil has been formed of the sediment carried down by the transporting action of the river water. We have, near London, alluvial land along the banks of the Thames, and Medway, and the Romney Marsh. On both sides of the Humber, in Yorkshire and Lincoln, there are large tracts of alluvial soil.

Lava forms another transported soil consisting of a silicate of alumina, with potash, soda, oxides of iron, and manganese, lime, magnesia, &c., and yields fertile clays on disintegration. Soils of this description are found near Edinburgh, and in the north of England. The country around Etna and Vesuvius is very fertile—being a lava soil.

Again peat, although not a transported soil, bears no relationship whatever with the underlying rock. Peat frequently rests upon clay, and

has generally been formed by the overthrow of a forest tract by a severe wind and flood. This accumulation of vegetable matter interrupted the natural drainage of the district, forming a moist spongy condition of soil favourable to the growth of moss, &c. In Ireland there are upwards of 4,000 square miles of peat morass.

The sedentary soils formed of clay, sand, or lime, or of a mixture of these, have been formed from rocks *in situ*. In this country we have the London, weald, gault, blue lias, and plastic clays, and in the north we have the aluminous shales of the coal measures. But the richest clays are those found along the margins of rivers, as the tract of clayland extending six miles south of the Thames into Surrey. The boulder clay forms an inferior soil in Scotland, and so does the coal measure clay, being difficult to work.

There are the old red sandstone, new red sandstone, and green sand soils in many districts of England and Scotland. Limestone, chalk, and magnesian limestone are widely distributed in this country. The chalk hills extend east of a line from Flamborough Head to Dorsetshire. The mountain and magnesian limestones are found in the north and west, and lime is largely found in the lower oolite, which is a brashy light soil. The sedentary super-soil differs from the subsoil by containing organic remains. The subsoil is the soil immediately under the point to which cultivation extends

downwards. If the subsoil is composed of clay, or the old or new red sandstone, then the soil will be too moist, and if chalk or sand form the subsoil, then the soil will be too dry. It is a bad combination when both the soil and subsoil are porous or retentive, but it is a good combination when they have contrary characters, so that each mutually remedies the defects of the other. A rocky subsoil prevents deep cultivation, and a gravelly one allows fertilizing matter to wash through.

CHAPTER II.

MINERALS.

QUARTZ consists essentially of the oxide of silicon (SiO_2), being frequently mixed with other substances. This mineral is very abundantly found in all parts of the world; it is the principal constituent of granite, syenite, pegmatite, protogene, elvanite, all sandstones, trappean rocks, sands, &c. Its usual crystalline form is that of the six-sided prism capped by six-sided pyramids.

Felspar is an anhydrous silicate of alumina and potash, soda, or lime, and is abundantly found in all parts of the world. It is one of the constituents of granite, syenite, gneiss, trachyte, greenstone, &c. When decomposed it forms clays.

Orthoclase containing potash is found in the plutonic rocks, containing granite, &c.

Albite containing soda, and labradorite containing lime, are found chiefly in the volcanic rocks.

Mica consists of a silicate of alumina, with

potash, magnesia, lithia, oxide of iron, fluorine, &c. It is widely distributed, and is one of the constituents of granite, mica slate, &c.

Potash, or common mica, is characterized by containing silicate of potash and a little fluorine.

Magnesia mica, or biotite, contains about as much magnesia as alumina.

And lepidolite is characterized by containing lithia in small quantities.

The zeolites, so called from their melting before the blow-pipe, are hydrated silicates of the alkalies or alkaline earths except magnesia, generally containing alumina. They are generally found in the fissures of granite, gneiss or trap-rocks, and in amygdaloidal cavities formed probably by deposition from percolating water.

Basalt is composed of felspar and hornblende with a little iron. Its composition is similar to that of greenstone, but its crystalline forms show that it was more rapidly cooled than greenstone. It is of a dark grey or almost black colour. In the trap basalt the silicates of lime and magnesia take the form of hornblende, and in the newer or lava basalt the form of augite.

Greenstone is a trap-rock composed of hornblende and felspar. It is so called from its green colour. The crystals may be coarse or fine. When exposed to the action of the atmosphere it becomes of a dark brown colour and disintegrates.

Trachyte is a volcanic rock consisting principally of felspar crystals. Occasionally crystals of hornblende, mica, and augite are found imbedded.

Granite is an igneous rock consisting of crystals of felspar, quartz, and mica, confusedly mixed together. Granite differs from the trappean and volcanic rocks in containing an excess of silica that crystallizes as quartz, while the other have only sufficient to form hornblende and felspar with the bases. The felspar in granite may be either orthoclase, the flesh-coloured, or albite, the white variety, or a mixture of both. This mineral forms about one-half of the rock.

In syenite, hornblende substitutes mica, and in protogene talc substitutes the mica. It produces a fertile soil, as it contains all the elements necessary for the growth of plants under favourable conditions of temperature.

Gneiss has a similar composition to granite, but the components are arranged in layers. It merges into granite on the one hand and into mica schist on the other.

Mica slate consists of alternate layers of mica and quartz. The latter is like vein quartz arranged in thin layers, and the mica consists of scales often insensibly merging into clay slate. It is thought to be a metamorphic clay or shale deposit.

CHAPTER III.

THE CLASSIFICATION OF SOILS AND THEIR PROXIMATE CONSTITUENTS.

THE physical nature of a soil depends upon the proportions in which the proximate constituents—clay, sand, lime, stones, and vegetable matter—are blended.

Clay is a hydrated silicate of alumina. Pipe clay is almost free from impurities. It has a greasy feel and a greyish white colour. It is found in Devonshire and Dorsetshire. It contains about 38 per cent. of alumina, traces of lime, and about 3 per cent. of oxide of iron. Kaolin, or porcelain clay, contains more alumina than any other variety, being composed of about 40 per cent. of it, 47 of silica, and about 13 of water. It is produced by the decomposition of the felspar of granite rocks, and pegmatite, a variety of granite containing little quartz and less mica, furnishes this clay in greatest abundance. It may be represented by the formula—$Al_2O_3 2SiO_2 + 2H_2O$,

and is found in the granite districts of Devon and Cornwall. It is a fine soft clay, having a soapy feel, and crumbles to powder when pressed between the fingers.

But ordinary clay is usually associated with potash, soda, lime, iron oxide, carbonic anhydride, magnesia, &c., which impurities in the clay impart fertility to the soil, since pure clay will not support vegetation.

In heavy clay soils there is about 5 per cent. of alumina, and in ordinary cultivated land there is between 1 and 2 per cent. of it. Although alumina is comparatively unimportant as a plant food, yet it imparts to the soil several useful properties. It gives to clay the power of absorbing and retaining moisture, and renders it adhesive. It is found in combination with silica in clays, clay slate, felspar, mica, &c. But these rocks contain soda, potash, lime, &c., which are found in the clays formed from these rocks, rendering them fertile when these alkalies are in the soluble condition.

Clay has its advantages and disadvantages. Its merits are the introduction of valuable plant-food constituents into the soil, the retention of moisture enabling the land to resist drought. Its defects are its great adhesive power, rendering it difficult and expensive to cultivate; its great capacity for absorbing and retaining water renders the soil cold and late in maturing crops. In the wet state it is greasy and slippery under

foot. During dry summer weather it loses water, and cracks, forming fissures and lumps that are difficult to break up. A clay soil is improved by mixing it with sand, by liming it, or by "paring and burning." The sand opens up or divides the clay, it warms the land by its power of retaining heat, and it allows the water to pass more freely through the soil.

Lime, besides many other useful purposes which it serves when applied to clay lands, liberates the dormant constituents of the soil, rendering them available for plant food. For instance, if we mix lime with finely powdered clay or with pulverized granite we shall find that potash and soda are liberated. It also promotes the decay of combustible matter.

Again, the parings of the soil when burnt, and the resulting powder when spread over the surface, enhance the fertility of the land by rendering dormant plant food available.

Pure sand consists of small particles of quartz or silica (SiO_2). It is insoluble in water or acids, and fuses when heated into a vitreous mass. It does not absorb moisture from the atmosphere, and is quickly dried, retaining heat, and consequently imparting warmth to soils.

Sand may be silicious, calcareous, or micaceous. The silicious is the normal or quartz sand. A calcareous sand contains a considerable quantity of particles of lime in the form of chalk or shells, and a micaceous sand contains

particles of mica. Pure sand will not support plant life, but it gives to land many useful qualities. It enables the roots of plants to penetrate the soil more easily in search of food. It renders land more easily cultivated, and imparts warmth to it. It opens up the soil and allows water to percolate freely. When sand is wet it is moderately firm, and can be ploughed in furrows, but when dry it is easily drifted by the wind. It feels rough when rubbed between the fingers, and cannot be formed into a ball by pressure.

Sandy soils are loose, porous, light, and easily worked. Their great defect is the non-retention of moisture, and this is the principal reason why liquid manures produce such extraordinary effects on sandy soils. The Belgians have converted an almost sterile sandy soil into a fruitful one in this way. Sandy or light soils, when manured, are suitable for the growth of barley, oats, carrots, turnips, &c., but are unsuitable for beans or wheat. Sandy soils are improved by the application of marl or clay, by sheep-folding, and by the application of farmyard or artificial manures, which supply to these soils potash, soda, phosphoric acid, &c., plant food in which they are deficient.

Lime (CaO) is an alkaline earth. When pure, it is a caustic powder having an alkaline reaction, and resists the heat of the oxy-hydrogen jet without fusing. It is obtained by heating pure

carbonate of lime—Iceland spar, for instance—to full redness, when carbonic anhydride (CO_2) is dissipated, and quicklime ($Ca\,O$) is obtained. When water is poured on it, calcic hydrate or slaked lime is formed ($Ca\,H_2O_2$), the water and lime entering into combination, produce much heat. When only a little water is added to the quicklime it merely forms a dry, white powder, which, when heated, loses water, leaving the quicklime. Milk of lime is formed when more water is added than necessary to form the hydrate. Lime is slightly soluble in water, forming lime water. When water contains free carbonic anhydride, the carbonate of lime is soluble.

Carbonate of lime ($Ca\,C\,O_3$) is very common in both inorganic and organic nature. In the inorganic it is found as the amorphous chalk and limestone, and as the crystallized calc-spar, Iceland spar, aragonite, &c.

The chalk hills extend from Dorsetshire to Yorkshire and from Kent to Wilts. The carbonate is found in the oolite, the magnesian, and mountain limestones, and in the marls and marbles in many formations.

As lime is found in the ash of plants it is therefore an essential plant food, and requires to be applied to land deficient in lime. It is sometimes applied in the form of chalk, but before application to the land it is generally burnt and slaked with water. When applied to clay land it converts much of its dormant into

active constituents, and renders the soil more easily cultivated.

Soils containing much vegetable matter are improved by the application of quicklime, which hastens the decay of this matter into CO_2, OH_2, and NH_3. It neutralizes the effects of injurious acid substances in the soil, and renders harmless injurious salts of copper or iron. A limy soil is produced by the disintegration of limestone, and when this disintegrated rock has been drifted to clay or sandy land a marl is formed.

Calcareous soils are of a light colour, porous, and often deficient in moisture, particularly when they lie over a porous subsoil, but when the land is deep, as many of the mountain limestones are, then this defect is not so apparent. These soils are adapted for the growth of grass and turnips, but are not so suitable as clay for beans or wheat. With limestone there occur phosphoric anhydride, ferric oxide, calcium sulphate, silica, and traces of organic matter, so that the impurities of lime taken with the impurities of clay supply most of the elements required by plants.

Stones serve several useful purposes in soils. When present in abundance in clay they render it more easily cultivated by dividing and opening it up. By the disintegration of the stones fresh supplies of plant food are formed. The stones are portions of the original rock from which the

soil was formed, and vary with its nature. In chalk soils we find flints, and in alluvial land water-worn pebbles. The stones vary in size, and by the disintegrating process even the largest will in course of time crumble to powder like the present soil, which is not merely a mass of powdered rock, but the result of the action of various forces through long periods of time modified by the decomposition of organic matter.

Humous soils consist wholly, or to a large extent, of vegetable matter, as in bogs and forests. In peat vegetable matter forms almost the entire mass, imparting a dark-brown colour to soils that is observable in good land. Humus is a soft, porous, dark-brown substance, that may be observed in well-rotted leaves. It is a source of nitrogen and carbonic anhydride, which latter assists in the liberation of insoluble elements. Humus is not the cause, but the concomitant of a fertile soil. Lava soils are very fertile, though they contain no vegetable matter.

The English moors and Irish bogs are peaty or vegetable soils. Chatmoss, in Lancashire, is composed of plants imperfectly decayed, such as reeds, sphagnums, equisetums, and confervæ. The decay of these plants is arrested by the water, which excludes the air, filling the pores of the soil. They are converted into humic and analogous acids which are unavailable

as plant food, and from their antiseptic powers they preserve animal and vegetable matter from decay.

The first step towards the reclamation of bogs is drainage, so as to allow free access of air to promote the decay of the vegetable matter. Next the application of lime to still further promote its disintegration. Then burning so as to increase the quantity of the ash constituents, and finally the application of sand or clay to still further increase the inorganic matter, and to impart weight and firmness to the soil.

The Norfolk fens have been rendered fertile by a top dressing of the clay which formed the substratum.

Soils may be divided into eight principal classes, and these again into three each, excepting the last, from the amount of vegetable matter present.

Poor soils contain	from	0 to .5	per cent.	of humus
Intermediate	,,	,,	.5 to 1.5	,,	,,
Rich	,,	,,	1.5 to 5	,,	,,

The following are the eight classes of soils, viz. :—

(1) Sandy (under 10 per cent. of clay).
(2) Loamy sand (10 to 20 per cent. of clay).
(3) Sandy loams (20 to 30 per cent. of clay).
(4) Loamy (30 to 50 per cent. of clay).
(5) Clayey (above 50 per cent. of clay).
(6) Marly (from 5 to 20 per cent. of lime).

(7) Calcareous (above 20 per cent. of lime).
(8) Humus (above 5 per cent. of organic matter).

In relation to the amount of silica ($Si\ O_2$) present, soils may be divided into :—

(1) Sandy soils	containing	from	80 to 94	per cent.	of silica.
(2) Clayey	,,	,,	,,	70 to 80	,,	,,
(3) Loamy	,,	,,	,,	60 to 70	,,	,,
(4) Marly	,,	,,	,,	40 to 60	,,	,,
(5) Limy and marly			,,	5 to 40	,,	,,

Alumina scarcely ever exceeds 15 per cent. of the soil :—

Clay soils contain about 6 per cent.
Sandy soils contain from 1 to 5 per cent.
Limy and marly soils contain from 1 to 8 per cent.

Calcic carbonate ($Ca\ Co_3$) varies in soils from traces to 90 per cent. :—

Loamy and clayey soils contain from 1 to 3 per cent.
Defective soils contain less than 1 per cent.

CHAPTER IV.

ELEMENTS: PLANT ASH AND ANALYSIS OF SOILS.

THE following table exhibits the constituents of volcanic rocks, soils, and plant ash :—

Volcanic Rocks.	Soil.	Per Cent.	Plant Ash.
Magnesia ..	Magnesia ..	from .05 to 1.5	Magnesia
,, ..	Manganese	traces........	Manganese (traces)
Alumina....	Alumina....	from 1.0 to 15.0	Alumina (traces)
Lime	Lime	,, 0 to 90.0	Lime
Phosphorus	P_2O_5	,, 0 to 1.5	P_2O_5
Potash	Potash	,, 0 to 3.0	Potash
Iron oxide (Ferrous)..	Iron oxide (Ferric)	....	Iron
Silica	Silica	,, 5 to 94.0	Silica
Soda	Soda	,, 0 to 2.0	Soda
Sulphur	SO_3	small amount	SO_3
,, ...	Bromine....	,, ,,	Bromine (traces)
,, ...	Chlorine....	,, ,,	Chlorine
,, ...	Iodine......	,, ,,	Iodine (sea and sea shore plants)
,, ...	Fluorine....	,, ,,	Fluorine (in grasses, &c.)

The following inorganic elements are found in plants, viz. :—Chlorine, bromine, iodine, sulphur, potassium, sodium, phosphorus, calcium, magnesium, silicon, iron, manganese, and fluorine.

Carbon, hydrogen, oxygen, and nitrogen are found in plants, and are supplied as OH_2, CO_2, and NH_3.

Of these elements O, H, N, C, S, P, K, Ca, Mg and Fe are active constituents, and Si, Cl, I, F, Na, Li, and Mn are nearly dormant, while Br, Cs, Rb, Cu, Pb, As, Zn, Te, and Ba are wholly dormant.

If we take an ordinary soil we shall find that from .1 to .27 per cent. is soluble in water, from 6.5 to 10.8 is soluble in acids, and from 77 to 87 is insoluble. Organic matter varies from 2 to 13 per cent.

A rough analysis of a soil may be made by drying a certain weight, when the loss in weight gives the water present. Burn it on a piece of clean iron, when it blackens, if carbonaceous matter is present, and the blackness disappears as the volatile elements, carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus pass off. The loss in weight gives the amount of vegetable or organic matter present in the soil. By passing the residue through a fine sieve, pebbles, &c., are separated from the finely-divided soil. Weigh both. When this soil is put in water it partly falls to the bottom, partly floats, and is partly dissolved. The portion that falls to the bottom is heaviest, and consists of sand, silicates of alumina, with varying proportions of lime, potash, magnesia, soda, &c. The portion that

floats in the water for some time consists of the impalpable powder clay which may be poured off, leaving the sand, &c., behind, which dry and weigh; separate the impalpable powder from the water, dry and weigh; evaporate the water, when the solid residue left behind constitutes the soluble mineral constituents.

By ordinary chemical analysis, into which we cannot enter here, the farmer can tell from the proportion of the soil soluble in water, and also in weak acids, what constituents are present in a maximum, and what in a minimum state as available plant food. And from this knowledge he will not fall into a common error of manuring at random, and apply expensive constituents to a soil in which these constituents are already present in a maximum, but will only apply those manures which supply the constituents that are either absent or in the insoluble form, or present only in a minimum. The law of minima is one which farmers would do well to study, and thereby save themselves from unnecessary expense. Although the chemical analysis of a soil cannot always be absolutely depended upon, yet it is one of the factors that should never be overlooked in the estimation of the relative values of land.

It is almost as necessary for the farmer to know the real condition of the soil of his farm as it is for the merchant to know the real state of his affairs, as shown by a list of assets and

liabilities. When the state is known, an honest and prudent merchant will not overdraw his account, nor will a good farmer over-estimate or exhaust the resources of the soil. He will not, for instance, attempt to grow a crop from land in which a sufficiency of the constituents required by the crop does not exist, and so run the risk of losing his reserve fund, if he is fortunate enough to have one upon which to fall back.

It is found on burning any plant that the quantity of ash varies from .4 in apples or cucumbers to 8.7 per cent. in sesame seed, and from .2 in human milk to 5.0 in cheese. However, the ash usually averages about 3 per cent. of the whole plant, leaving about 97 per cent. of organic matter. In wheat seed there is about 1.2 per cent. of ash or mineral matter, consisting of silica, .4; soda, .24; potash, .23; lime, .1; magnesia, .09; sulphuric acid, .05; phosphoric acid, .04; alumina and iron, .03; and chlorine, .01. Again in wheat straw there is silica, 2.9; lime, .24; phosphoric acid, .17; alumina with iron, .09; sulphuric acid, .04; magnesia, .03; chlorine, .03; soda, .03; and potash, .02; making 3.55 per cent. of ash. In beans the phosphoric acid is .3, instead of .04 as in wheat, the potash becomes double and the soda more than treble what it is in this grain. Thus the amount of mineral constituents varies in different plants, and also in different parts of the

same plant. These mineral substances of the ash occur in the plant in the form of silicates, phosphates, sulphates, chlorides, &c. Silica occurs largely in the straw of the cereals and other grasses, giving firmness to their stems. About one half of the ash of the equisetum consists of silica. Silicate of potash, which is soluble, is taken up by the roots of plants, and in the sap may come in contact with oxalic acid, or some other vegetable acid forming oxalate of potash or some other salt, leaving silica or silicic acid to be deposited in the cells of the plant. Silica is found in small quantities in the hair, skin, nails, horns, feathers, and teeth of animals.

Potash and soda occur to a greater or less extent in most plants; sometimes they are about equal, as in the grain of oats and wheat. In the field bean there is about twice as much soda as potash, and in other plants the reverse holds good. Again, in some plants there may be very little potash and a great deal of soda, and *vice versa.*

On burning various species of salsola, halimocnemum, salicornia, &c., large quantities of soda are yielded. Those plants growing near the sea contain soda, and those inland contain potash. And in some plants, like the *Plantago maritima*, potash predominates when growing inland, iodine disappearing; while, when growing near the shore, soda predominates, with some iodine. Again, it is remarkable that

some marine plants, although growing in the midst of an excess of soda, contain in their composition an excess of potash. There is a large proportion of potash and soda in maize straw, beetroot, Jerusalem artichoke, potatoes, and turnips. Potash is contained in the blood corpuscles. Water cress, lettuce, &c., contain the nitrate. Common salt (Na Cl) occurs to a great extent, in the soluble form, in all animal tissues, and it forms six parts in a thousand of the blood, *i.e.* more than a half of its saline matter.

The salt taken in food supplies chlorine to form hydrochloric acid in the stomach for digestive purposes, and potassic chloride found in the red blood corpuscles. The sodium goes to form the phosphate of soda of the blood, and soda for the bile. It also exerts an influence on the changes of the tissues. Common salt forms half a pound out of the 11½ lbs., the total mineral matter in the human body. The phosphates of potash and soda occur in the blood, and animal tissues being derived from plants, the muscles select phosphate of potash and the cartilages phosphate of soda in preference. Phosphate of potash is found in seeds. The citrate, oxalate, tartrate, and malate of potash occur in fruits. The carbonate of soda is a plant food, and is found in blood in small quantities, and serves the purpose of dissolving flesh-formers, such as fibrine, caseine, &c. It

may also assist the respiratory process, and when taken as food by hyacinths it reddens them.

Lime occurs to a greater or less extent in all plants. Meadow clover, pea straw, potato haulm, sainfoin, and tobacco contain lime in considerable quantities. The raphides, or acicular crystals found in the cells of many plants, contain lime, which in the rhubarb take the form of an oxalate. An incrustration of the carbonate is found on the surface of plants as in the case of the characeæ. This carbonate is found in the bones of animals and in animal concretions. The phosphate of lime occurs in every animal tissue, and also in fruits, seeds, &c. It forms about half of the substance of bone, and is contained in the vegetable flesh-forming substances—albumen, caseine, and fibrine, from whence it is obtained by animals. In caseine it occurs to the extent of 6 per cent., and varies from 1½ to 2 per cent. in nitrogenous foods. Calcic fluoride is found in small quantities in the teeth, bones and animal tissues, and is derived from vegetable foods. In a full-grown man the total mineral matter is about 11½ lbs.; of this 8¾ lbs. consist of phosphate of lime. Phosphoric acid is contained in the blood corpuscles. Man discharges a portion of the phosphorus of his food in the urine, and the horse, cow, and sheep, principally in their excrements. The salts of magnesia gene-

rally accompany lime salts. The phosphate is found sparingly in the animal fluids, muscles, and bones, and the carbonate is also found in the animal body in very minute quantities. Magnesia and its salts are essential plant foods, and are found to a greater or less extent in most plants. In the cereals the quantity of magnesia almost equals that of lime.

Sulphuric acid forms salts with other elements, such as potassium and sodium in plants, and sulphates of these elements are found in the animal fluids. Sulphates are also obtained from water by animals, and the sulphates of the body may be formed from the sulphur of the albuminoids. Plants, although they may grow in soils where there is an excess of alumina, yet the percentage in their ashes is always very small. Iron occurs in the ashes of all plants that are used for food, probably in combination with various organic acids. It is found in the blood (hæmoglobin), milk (1 part in about 60,000), gastric juice, in the black pigment of the eye, in the hair, &c. Lead, manganese, and copper are found in human bile. These substances are doubtless introduced accidentally. It is not unusual for copper to occur in baker's bread. Sodic sulpho-cyanide occurs in the saliva, although it does not in food.

CHAPTER V.

IMPORTANT SOIL ELEMENTS AND COMPOUNDS.

SOILS contain the metals calcium, aluminium, potassium, sodium, magnesium, iron, manganese, barium, strontium, &c., united with oxygen, silicon, carbon, sulphur, phosphorus, fluorine, &c.

Calcium is found in the following natural compounds, viz. calcic carbonate, the double carbonate with magnesium, as a sulphate in selenite, gypsum, and as a fluoride in fluor or Derbyshire spar ($Ca\,F_2$).

Calcium is a light yellow malleable metal. In dry air the oxide $Ca\,O$ is formed. The oxide is also formed when it is heated in the air. It decomposes water, forming the hydrate $Ca\,H_2\,O_2$, and this compound is also formed when calcium is exposed to moist air. Lime is found in all plants. It exists as oxalate crystals in the cactus tribe and in the roots of rhubarb, as well as in the raphides found in the cells of plants. Calcic sulphate occurs abundantly in

nature as gypsum, selenite, &c. This sulphate is formed as a white powder when a solution of a sulphate is added to a concentrated solution of a calcium salt. It is soluble in about 480 parts of water. To this solubility its value as a manure is due. It is used to a greater extent as a manure on the Continent and in the United States than this country. It is ground in mills to a fine powder and applied to the land. It produces a decided effect when applied for clover, and if wheat follows it participates in the beneficial action; however, an excess is prejudicial, as has been found in cases where a subsoil consisting of calcic sulphate has been ploughed up. Gypsum occurs abundantly in many parts of the world in very different formations, as in the metamorphic, the secondary, and tertiary rocks. In England it is quarried from the red marl just over the rock salt. In some places it is found above the chalk and in reniform masses in marl and clay. Selenite, the crystallized variety, is found in the London clay at Sheppey. Calcic phosphate ($P_2O_2Ca_3O_6$), or the tricalcic diphosphate, is found naturally as coprolites, phosphorite, apatite, and sombrerite.

Coprolites are found in the secondary and tertiary formations. They are the fossilized excrements of saurians. They often contain the remains of bones, shell, teeth, and other indigestible parts of the food on which these

animals lived. They contain a large quantity of phosphate of lime, and are met with in Norfolk, Suffolk, Cambridge, Bedford and Buckinghamshire, where they are quarried for the manufacturers of artificial manures. They are also met with in France, Russia, &c. The term coprolites now includes the fossilized remains of ammonites, belemnites, echinodermata and terebratula. Coprolites usually contain about 45 per cent. of lime, 25 of P_2O_5, 18 of oxides of iron and alumina, 8 of silicious matter, and 4 of water.

Phosphorite is associated with mica slate or gneiss in granitic rocks. It occurs crystallized, having a glossy lustre and a brittle texture. It is difficult to reduce to powder. It contains about 70 per cent. of calcium phosphate. There are deposits in many countries, which are used for manure.

Apatite exists in nearly all the geological formations, and is specially abundant in the metamorphic rocks. It is found in veins and dykes in the rocks and in spheroidal masses. In the silurian rocks in North Wales it is 18 inches thick. In Estremadura, in Spain, the cretaceous formation contains it, and in Norway it occurs in conjunction with granitic rocks. It is also seen in some of the tin mines of Cornwall, Bohemia, and Saxony. It is of a red, green, blue, or white colour, and is extensively used as a manure.

Sombrerite, or rock guano, is called after the island of Sombrero in the West Indies, about sixty miles east of St. Thomas. This rock covers the greater part of this as well as other islands in the West Indies. Under the name of sombrero guano it is extensively used for the preparation of artificial manures. It is ground to a fine powder and acted on by sulphuric acid, which converts the phosphorus into the soluble condition thus : $Ca_3\ 2\ PO_4 + 2\ H_2\ SO_4 = 2\ Ca\ SO_4 + H_4\ Ca\ 2\ PO_4$, which latter compound is soluble, and is therefore available plant food. This manure is especially beneficial for the growth of wheat, oats, barley, turnips, &c.

Aluminium, as an oxide in combination with the oxide of silicon, forms one of the principal constituents of the earth's crust. It is found in nature in clay shale, felspars, granite, hornblende, basalt, gneiss, mica, kaolin, fullers' earth, cryolite, &c. Aluminium is a white metal having a bluish tinge, being very malleable and ductile, and having a specific gravity of 2.5. Alumina (Al_2O_3), its oxide, has been already referred to in connection with clay soils. Its other compounds are not of sufficient agricultural importance to deserve a separate description.

Potassium (K) has a decided metallic lustre and a bluish-white colour. Its specific gravity is less than that of water, being .86. At the freezing point of water it is brittle, and has a crystalline fracture ; at 15° C. it has the con-

sistency of wax; at a few degrees below 60° C. it becomes liquid; and at a red heat it forms a green vapour. When exposed to the air the oxide and hydrate are formed, and when thrown on water the latter is produced and hydrogen evolved. When heated it burns with a purple flame. Potassium occurs as a silicate ($Si\,K_4O_4$) in nature, combined with silicate of alumina in mica, felspar, granite, &c. This silicate is decomposed by carbonic anhydride thus:— $Si\,K_4\,O_4 + 4\,CO_2 + 4\,H_2\,O = Si\,H_4\,O_4 + 4\,C\,O\,H\,O\,K\,O$ hydric potassic carbonate which is soluble in water, and passes into the soil, from whence it is taken up by the roots of plants, and is found in their sap as organic acid salts, such as the malate, acetate, tartrate, &c. Potassic carbonate ($K_2\,C\,O_3$) occurs in soils, and is prepared by burning plants, especially the young shoots and leaves. The organic salts of potassium, on burning, are decomposed and converted into the crude carbonate or ash. Potash varies in soils from a trace to 3 per cent. It is deficient in sandy and peaty land, and is found accompanying alumina.

Sodium (Na) is a bluish-white metal, having a specific gravity of .97, and resembles potassium in many of its properties. It fuses just below the boiling point of water, boils at a red heat, and burns with a yellow flame. With air and water it acts like potassium. Soda is most abundant in soils near the sea, but is

not so important a constituent as potash, and it varies from a trace to 2 per cent. Salt (sodium chloride) (Na Cl) is found in the solid form, as rock salt, in Cheshire, near Belfast; at Wieliczka in Poland; near Montserrat, in Spain, there is a hill composed of it; the island of Ormuz, in the Persian Gulf, is formed of it; and vast quantities are found in other parts of America, Africa, and Asia. Salt is also found in brine springs and in sea-water, in which it occurs to the extent of 4 oz. to the gallon. There are natural brine springs at Nantwich, in Cheshire, and at Stoke and Droitwich, in Worcestershire. This briny fluid has a specific gravity of 1.2, and contains sulphates of sodium, calcium, and aluminium, and small quantities of magnesic chloride and sodic iodide. Rock salt also contains various impurities, which are the cause of its different colours. Salt is an essential constituent of animal food, and in one part of Africa salt ranks next to gold in value, and a handful will purchase a slave, hereby showing that it is an absolute necessary. It should be mixed with the food of horses and cattle when stall-fed, and when animals are grazing in the field they should have access to lumps of rock salt, as the want of it may lead to various forms of disease. It is also found in all the secretions of the body, and on account of its great solubility and the freedom with which it passes through animal membranes it is especially liable

to escape by the skin and the kidneys; hence the necessity for the supply of a larger quantity than that found naturally in articles of diet. It materially assists in the digestive process. Salt is also a plant food, and should be supplied as a manure in cases which will be dealt with afterwards.

Sodic nitrate ($Na\,NO_3$) occurs as a natural product on the surface of the soil at Tarapaca in Peru, Atacama in Bolivia, and other districts where the aridity of the climate preserves it from entering into solution. In Peru the beds are sometimes 7 feet thick. This salt contains only about 5 per cent. of impurities. It has a rhombohedral form, is very soluble in water, and is a valuable fertilizer, being sold here for about £30 per ton. Sodic carbonate (Na_2Co_3) before the introduction of Leblanc's process by which it is obtained from salt ($NaCl$), was obtained from barilla and kelp, the ashes of certain sea plants, and from the natron lakes of Egypt. It is also found in the geysers' waters in Iceland, in the Hungarian lakes, in America, and sometimes as an efflorescence on the soil.

Magnesium (Mg) is a malleable and ductile metal, like silver in colour. Dry air has little, if any, effect on it, but when moist it oxidizes slowly. It has little action on water at ordinary temperatures, but, when boiled with it, a hydrate is formed and hydrogen given off. Magnesium has a specific gravity of 1.7. It is of frequent

occurrence in nature as a compound, and is found as a bromide, carbonate, chloride, hydrate, nitrate, phosphate, and sulphate. It occurs as a silicate in many minerals, such as augite, hornblende, &c. The bromide is found in mineral springs and sea-water. The carbonate occurs naturally as magnesite, and in combination with calcic carbonate forms magnesian limestone or dolomite. Magnesian limestone soil is found in Durham, York, and Nottingham, and other parts of the United Kingdom in the Permian formations. The Houses of Parliament are built of this stone obtained from Derbyshire. It can be easily distinguished from limestone by its comparatively slight effervescence with acids; when used as a manure in the same way as lime it does not appear to increase the fertility, but tends rather to burn the crops. Magnesic phosphate ($P_2 O_2 Mgo_3$) is a constituent of wheat and other seeds and plants. It is also found in the bones of animals, in urine and guano. Magnesic sulphate ($Mg S O_4$) occurs in mineral springs, as Epsom salts, and in sea-water. It is sometimes applied as a manure, and doubtless is of considerable utility when the soil is deficient in magnesium.

Iron is more abundant and more widely diffused than any other metal. It is found in combination with almost every rock to a greater or less extent. It is generally found in natural waters as a carbonate, but sometimes as a

chloride, and even a sulphate. Since it is so universally diffused in every soil, it is never deemed expedient to apply it to land under cultivation. It is one of the active and necessary constituents of animals and plants. The production of iron from its ores forms one of the great industries of this country. Iron also forms the material out of which most agricultural implements are made, and as it is so common and well known, it is unnecessary to say more about it here, except that it occurs in soils as a carbonate, oxide, or sulphide, and that ferrous carbonate can be absorbed into the vegetable tissues.

Silicon, next to oxygen, is the most abundant element, forming more than one-seventh of the earth's crust. It bears a remarkable resemblance to carbon in many of its properties. It forms a large part of the plutonic, trappean, and volcanic rocks. With oxygen, it produces quartz, flint, sand, &c., and with many metals it yields silicates. It is a necessary and important plant food, but in most animals only mere traces of this element are found.

Carbon is widely diffused in all the three kingdoms of nature. It occurs uncombined as diamond, pure crystallized carbon, and in the form of graphite. It is the most abundant element in plants, forming from 40 to 50 per cent. of those usually cultivated for food supply. The soil contains carbon as in

humus, and all peaty soils contain it in abundance, but it is insoluble and is unavailable plant food, until it is converted into carbonic anhydride. It assists indirectly in the nourishment of plants by absorbing gases that allow certain combinations to form. Organic matter or matter containing carbon is present in all except lava soils producing good crops. In peaty soils there is upwards of 90 per cent. of vegetable matter. Loamy soils contain from 10 to 14 per cent., while sandy soils often contain less than 1 per cent. of organic matter, and in cold clays it is deficient. The moulds produced in milk, sugar, and mycoderma vini cellular plants are entirely composed of organic matter, no ash being left on combustion. Carbon is found in great abundance in combination with oxygen, forming carbonic anhydride in the atmosphere; this compound is also given off in the respiration of animals. Carbonic anhydride exists in the air to the extent of 4 volumes in 10,000. It is a colourless gas, having a pleasant taste and smell, but it is irrespirable when breathed in quantity, producing death. However, when taken into the stomach, it positively produces a beneficial and invigorating effect, as when aërated waters are drunk. It is incombustible, since it cannot unite with more oxygen, being in the state of highest oxidation, and will not support combustion, as may be seen by putting a lighted body in this

gas. It is the principal product of combustion when bodies are burnt, the carbon of the body uniting when heated with the oxygen of the air, forming CO_2. Besides being given off in the respiration of animals, it is emitted by the skin, and is present in the blood, urine, and other fluids. It is evolved from fissures in the earth's surface, as in Java, Prussia, &c. It is formed in large quantities by explosions in mines; is given off in fermentation, and is also evolved when calcic carbonate is burnt in kilns. It forms a constituent in a great number of minerals termed carbonates, as carbonate of lime, carbonate of iron, &c., &c. Carbonic anhydride is an essential plant food, and is obtained by plants from the atmosphere by the leaves, and mixed with water by the roots. All animal and vegetable compounds contain carbon, combined with oxygen, hydrogen, nitrogen, as essential with other elements as sulphur, phosphorus, and a large number of other substances.

Phosphoric acid exists in very small quantities in limy, marly, and peaty soils. There is usually less than 1 per cent. even in fertile land, the average amount being about .4 per cent.; however in some clays it amounts to 1.5.

Nitrogen is one of the most widely diffused elementary substances, as it forms by volume nearly four-fifths of the atmosphere. Nitrates are natural products found in many parts of the world. In combination with hydrogen, it forms

ammonia (NH_3), and this is the form that nitrogen assumes on the decay of organic matter, and in this form it is taken up by plants. There are various compounds of oxygen with nitrogen, and of nitrogen with carbon, hydrogen, and oxygen as in the natural alkaloids that are found in plants. There are also compounds of carbon, nitrogen, and hydrogen as in the amides. Nitrogen with carbon, hydrogen, oxygen, and sulphur form albumen, a nitrogenous proximate constituent of plants and animals, and phosphorus is present in some proteid bodies and absent in others. Those vegetables containing most nitrogen as a rule are the most nutritious.

CHAPTER VI.

THE PHYSICAL PROPERTIES OF SOILS: CLIMATE AND DISTRIBUTION OF PLANT LIFE.

TENACITY is a quality that soils should possess in some degree. When it does not exist the soil is liable to be blown about, as in purely sandy soils, in deserts, &c. When land is highly tenacious, as in some clay soils, then it is difficult or incapable of cultivation. And some plants —mangel, turnips, &c.— do not grow well in tenacious clays, since they cannot grow laterally to much extent. Clay soils by due admixture with sand or lime become less tenacious and better adapted for the growth of crops. The smaller the particles of matter of which a soil is composed the greater its porosity; hence clay in which the particles exist in a minimum state of division possess a maximum porosity. This is the reason why it retains moisture to such a high degree. The particles of which it is composed being so minute, and the distance between them

being very small, the moisture is retained in the same way as water is retained and ascends in tubes of very small bore. The particles of which sand are composed being large, in comparison with the particles of clay, do not lie so close together; hence water passes freely through the former in comparison with its passage through the latter. Water will rise in clay to a height of about 3 feet above its level, while in sand it will only rise about half this height. It is this property of soils that enables them to retain sufficient moisture for the growth of vegetation. Again, the same capillarity of the land prevents useful fertilizing matter from being washed through it, and thereby carried beyond the reach of the roots of plants. And liquid manure and sewage, on passing through certain depths of soils, become thoroughly purified; the capillarity being aided by the oxidation of the atmosphere, and the fertilizing matter being retained. For instance, when aqueous solutions of phosphates, alkaline salts, &c., are filtered through ordinary soils, it is found that the fertilizing matter is attracted and retained, while the water passes through almost pure. In fact clay, like charcoal, makes a very good filter for bad water. Thus when land is allowed to lie fallow, or at rest, the constituents that are formed by decomposition, and it may be otherwise applied, accumulate, being continually washed into it by rain,

the soil acting as a filter and retaining all the valuable constituents until they are taken up by the roots of the plants forming the next crop. A good soil unless accompanied by a good climate is worthless. There may be in polar regions good land, but as the climate there is so severe it is impossible to cultivate it, and, moreover, labour would be unavailing, as plants will not grow. Again, in other countries the climate may be good and the soil may be barren. Climate primarily depends on the production of heat, light, and moisture, and as the heat of the sun increases in summer the more active and rapid is vegetable growth. As we approach tropical regions the energy of the sun increases in proportion as his rays become more and more direct, and in a similar degree does the luxuriance of the vegetation when the soil is fertile. When the rays of the sun fall obliquely, which they do more and more as polar regions are approached, until they fall parallel with the surface, little or no heat is taken up by the soil. Again, when there is a declivity sloping towards polar regions very little heat, if any, is taken up by the surface. Siberia slopes towards the north, and consequently any good soils that may exist there do not receive sufficient heat to produce favourable crops. And in our own country, when a district slopes to the north it receives little heat, which is lessened by exposure to cold north and easterly winds. Again,

when a fertile district slopes to the south it receives the sun's rays more directly than neighbouring soils, and is sheltered from north and north-easterly winds, so that more luxuriant and vigorous crops are produced than those yielded by the surrounding country. Again, the higher a soil is above the level of the sea the lower is the temperature, until, as we ascend mountains, we come to the region of perpetual snow. For every elevation of upwards of 500 feet there is a decrease of 1° C., and in passing from the hot plains of tropical countries to the line of perpetual snow, we pass through all the gradations of temperature, as in passing from the equator to the poles. A height of upwards of 1,000 feet in this country is sufficient to prevent wheat from ripening, and a height of 1,500 feet renders the growth of oats, barley, and the hardier crops precarious. If the earth were a sphere entirely covered with land, having no inequalities, it is plain that latitude would be a correct index of temperature; but from the unequal distribution of land and water, the inequalities on its surface, and various other causes, latitude is an uncertain guide. Take, for instance, the isotherm of 10° C.; we find that it advances slightly obliquely in a northerly direction through Asia till it arrives at the Crimea, from whence it passes through Vienna, Brussels, London, Dublin, then north-west through Ireland,

and then obliquely southward across the Atlantic to New York, from whence it trends north-west to Vancouver's Island, going obliquely south through the Pacific Ocean. The tracing of this isothermal line and others proves that the west of large masses of land are warmer than the east coasts, that the sea is warmer than the land, and that the Atlantic is warmer than the Pacific Ocean. The study of isothermal lines in our own country is interesting. In summer the lines of equal heat run almost due east and west, however they are slightly inclined to the north-east and south-west, showing that the temperature of the east of England is higher than the west in summer. This is due to the east winds bringing heat in summer from the heated Continent, while the south-west winds bring rain. About London the temperature is highest in summer, and it gradually lessens as we go to the north of Scotland, where the temperature is about 6° C. lower. In winter, on the contrary, we find that the temperature on the west of Great Britain is almost uniform, and is more than 1° C. higher than on the east coast, diminishing in the direction of west and east instead of south and north as in summer. On account of this uniformity from south to north in winter, places lying to the north of Scotland enjoy a higher temperature than does London, which lies towards the east coast. And the

south-west of Wales and Cornwall are warmer, being about 3° C. higher than the remainder of the west coast. The temperature is lowest in the central parts of the country, and gradually increases as we approach the sea, thereby showing that the mild winters we enjoy in this country depend mainly on oceanic influences. In spring the lines of equal heat run in a south-east and north-west direction, Belfast, Liverpool, and London having nearly the same temperature. In autumn these lines are curved, the curves ascending to the north towards the east coast of England and the west of Ireland, and descending south towards the west of England and the east of Ireland, thereby showing; that eastern England and western Ireland are warmer than the opposite portions during autumn. And as we go north these curves become more and more convex towards the south. In the matter of rain as well as temperature the climate of the British Islands varies considerably from west to east. In the highlands of the west of Ireland and Great Britain the rainfall is much greater than in the east of these islands, on account of the prevalence of south-west winds which bring numerous clouds copiously charged with moisture from the Atlantic Ocean, that give up their excess of aqueous vapour to the hills on the west in the form of rain. In consequence of this the average

rainfall is about 55 inches annually in the West Highlands, Cumberland, Wales, and Cornwall, while it is only about 25 inches for the rest of the country. At Seathwaite, in Cumberland, the average annual rainfall is about 130 inches, and in some parts of Perthshire it is not much less. The west of England is therefore better adapted for grazing, and the east for the growth of cereals. The mildness and salubrity of the English climate is due in a great measure to its insular position, to the Gulf Stream, and to the predominance of south-west winds. For six months the temperature ranges from 2° C. to 9° C., and for the remainder of the year it ranges from 10° C. to upwards of 16° C., giving a temperature that the Registrar-General has shown to be the healthiest. So that the climate of England, as a whole, is one of the best in the world, and very much better than many people try to make out. Happily, in this country, we have not many bogs and marshes giving rise to night mists that chill the soil and render the atmosphere injurious to health. And lakes, having a similar effect to marshes, though in a less degree, are confined principally to Cumberland in England. Again, in this country we do not require large forests to maintain the humidity of the soil. In some of the West India Islands, and in the east of the United States, the destruction of forests has lessened the rainfall in such a

degree as to cause droughts that were unknown previously. Forests are also often useful for shelter from cold winds. However, the clearance, drainage, and cultivation of the soil has generally a beneficial effect on the climate. Plants prevent the soil from being highly heated by radiation, which cools the vegetation and condenses the moisture of the air, rendering temperature more equable. A ploughed field will absorb and radiate more heat than a grass field. Water does not absorb or radiate as much heat as cultivated land. Again, a desert absorbs and radiates heat more than any other surface. The colour of the soil has also a considerable effect on the temperature, for light-coloured soils do not absorb heat in the same degree as the darker coloured. Plants, with certain exceptions, such as the African deserts, &c., are found in all parts of the world, from the equator to the poles, and from the base to the tops of the highest mountains, at the greatest depths of the ocean, and even in the hot geyser waters of Iceland, but different plants require different classes of soil, different temperatures, and different positions. Some plants grow best on clayey, some on sandy, some on calcareous and other soils. Many plants will only grow or grow best in tropical or torrid regions, others in temperate, and others in polar regions. The *Palmella nivalis*, lichens and mosses are peculiar to the Arctic regions.

Birch, pine, fir, furze, broom, heath, &c., are confined to the temperate regions. Liquorice, asparagus, wormwood, &c., are peculiar to the European steppes; birch, pine, willow, &c., to the Siberian steppes; prickly shrubs and scanty grass to Central Asia; British plants to Central Europe; caryophyllaceæ, labiatæ, evergreens, &c., to the shores of the Mediterranean. The vegetation of North, West, East, and South Africa is peculiar; so are the fig, coffee, senna, and dates to Arabia; the banana, banyan, cocoa-nut, palm, mango, orange, plantain, vine, &c., to India; spices to the Indian Archipelago, and ferns to New Zealand and Australia. The sugar-maple, the magnolias, pitch pine, and cinchona, are confined to certain districts of America, and tea is chiefly grown in China and the Japan Islands. And returning to the British Islands we find that there is a peculiar vegetation in the west and south-west of Ireland corresponding to that of the north and west of Spain. The vegetation of the south-east of Ireland and south of England resembles that of the Channel Islands and the north-west of France. The south-east of England is similar to the north-east of France. The tops of the highest British mountains have a vegetation that is Scandinavian in its origin, while most of the common plants of the cultivated districts in England are Germanic. From the poles to the equator the

growth of plants roughly divides the surface into regions corresponding with certain zones of climate. Thus the arctic, sub-arctic, cold temperate, warm temperate, sub-tropical, tropical, and equatorial zones roughly correspond with (1) lichens, mosses, &c.; (2) birch, fir, and pine; (3) oak, wheat, and deciduous trees; (4) wine-grape, evergreen trees, &c.; (5) laurels, myrtles, coffee, sugar-cane, &c.; (6) fig, olive, tree-ferns; (7) palms, spices, and bananas. But many plants are not confined to any particular zone; for instance, wheat is successfully cultivated over very wide limits of the earth's surface, as in the temperate parts of Europe, Africa, and Asia, in Canada, United States, South America, Australia, and in sub-tropical regions, where it succeeds best. The torrid regions are unsuitable for its culture except in elevated districts. It has been found in the case of wheat and other crops that the period of time required for them to arrive at maturity depends on the average temperature. Thus wheat grown in a country having an average temperature of 25° C. requires 100 days to ripen, 17° C. about 140 days, 15° C. 160 days, and 11° C. takes about 180 days. And within certain limits the higher the average temperature at which wheat is grown the better the quality; besides, the yield per acre is much greater.

CHAPTER VII.

SOILS SUITED FOR GROWTH OF VARIOUS CROPS.

MOST crops will grow on various kinds of soils subject to different climatic influences, but with regard to any particular kind of crop it comes to greater perfection, producing a larger yield on a specified soil and a certain description of climate. For instance, wheat grows best on clay soils, the heaviest crops being produced on loamy clays, but fair crops with good farming are produced on gravelly, light sandy, or chalky land. As wheat requires a firm soil for its growth when raised on light land, the necessary firmness is produced by folding sheep on turnips, or by rolling, which compresses it. This kind of land suits wheat when the climate is moist, otherwise it is unsuitable and soft deep soils increase the quantity of straw. Wheat cannot bear so much moisture as barley, nor barley as much as oats. The wheat grown in the eastern parts of Great Britain is superior in quality to that produced in

the west, where there is always more moisture in the atmosphere. In a proper soil wheat is produced in greatest perfection in warm and dry climates, so that the wheat grown in the most favoured localities in England never equals in quality that produced in warmer countries. On trial it has been found that English wheat is not suited for the manufacture of macaroni. An average temperature of about 13° C. for three or four months in the year is required for the successful production of wheat. It can be grown in countries having average temperatures during the time of its growth of between 8° C. and 24° C., but at the former temperature it takes about twice the time for growth (180 days) as it does at the latter, and as the heat increases above 8° C. to the other limit the period of growth is gradually reduced. It is the staple cereal crop in the temperate regions of Europe, Africa, Asia, Australia, and America. The soil of large tracts of Australia, Canada, and the United States is well adapted for its cultivation. It cannot be grown in torrid regions except in elevated situations, the parallel of 60° forms its northern limit in Europe, at elevations of 1,000 feet or upwards wheat will not grow in Great Britain, and the land must be in a high state of cultivation in all cases in this country.

Turnips, on the contrary, although they are often grown on clay soils, do not come to such

perfection as they do on rich, free, or lighter land, since the clay by its tenacity in a great measure prevents the expansion of the root. Besides, more labour is required in ploughing, harrowing, and drilling in stiff clay than in light and dry soils. It is injurious to the land to consume turnips on clay during the winter, and it is both detrimental to the soil and troublesome to cart away the produce in autumn. But the pressure produced by the cart wheels and the feet of sheep is beneficial to light lands. Scotland and Ireland are peculiarly suited for the growth of turnips, since moist, cloudy weather is most favourable for their production. Norfolk is also especially suited for their growth in soil and climate, and claims an exemption from a turnip disease termed "Fingers and Toes."

Barley succeeds best on light sandy or loamy loose land. The soils of Belgium, Holland, Denmark, and Silesia are especially suited for its growth, as these countries are characterized by their light lands. It is grown in Norfolk, Suffolk, Huntingdon, and the south-east counties of England for malting purposes, and it is only used as food in a few outlandish districts in Ireland and Scotland. It is cultivated in the Lothians, Berwick, Forfar, Kincardine, Aberdeen, Banff, Moray, Ross, &c., in Scotland. It requires a rich surface soil, hence it is generally sown after roots, especially turnips, which in the

eastern and south-eastern English counties are consumed by sheep in the field; but in many parts of Scotland this green crop is carted off the land, and additional manure applied to compensate for the droppings of the sheep. It does not thrive so well in the west of England as in the east on account of the excess of moisture, and it is liable to lodge with the rain. However, it is grown in Lancashire and Wales, but the Lincolnshire fens are too moist for it. The land intended for its growth should be ploughed shallow and harrowed so as to produce a fine top, since its roots are confined to the surface; hence the reason why it often advantageously follows wheat, because the food of each is abstracted from different portions of the soil.

Oats will grow on a greater variety of soils than barley or wheat. It is the first cereal crop grown in reclaiming moors and bogs. It will grow on sandy, clayey, and on most other kinds of land; however, the greatest yield is produced from rich and deep soils, and the least on thin sandy ones. In the latter class of soils it suffers from a lack of moisture as well as of food. It is grown in the west, south, and east of England, but it is produced in greater perfection in the north of England, Scotland, and Ireland. For oats the land should be ploughed deeper than for barley. A cold and moist climate is more favourable for its growth than a dry and

warm one. It does not suffer so much as other crops from defective or superfluous manuring.

Beans succeed best on heavy clay land like wheat, being extensively grown on the strong clay soils of Scotland and the clay districts of England. However, the winter bean succeeds fairly, and the common tick bean best on lighter soils. The Scotch or horse bean is grown largely in Scotland, where it gets on best.

The cultivation of beans in Ireland is principally confined to Ulster and Leinster. The soil should be moderately dry and therefore well drained, and ploughed deeply, as the roots of the bean penetrate further down in search of food than many other plants. A rich alluvial land, like that of Holderness, is favourable for the growth of beans, but perhaps taken altogether East Lothian produces heavier and better crops than that of any other part of the world, as there is a suitable soil, and the comparative coolness of the summer and the moderate and equally diffused rains are especially favourable. Its cultivation in the eastern counties is rather precarious, from the tendency to drought in these districts and the liability to insect attacks.

The pea, although belonging to the same class of plants as the bean, does not thrive well in the same kind of soil, but requires a lighter, especially a chalky or calcareous one,

or one to which lime or gypsum has been applied. It does not succeed well in a moist climate, as the seed is then apt to grow in the pods, and the plant is liable to lodge with the rain before they are filled. From this and other causes it is rather uncertain and precarious. It is produced on the chalky soils in England, but in Ireland it is not much grown as a field crop, as there is but a very small extent of soil in that country suited for its culture. It is extensively cultivated on the Continent and in America, and it is imported from Canada, Denmark, &c.

The potato can be grown on most soils, but the heaviest crops are obtained from a rich, loamy land. It can be planted after any other crop, and it is generally one of the first crops to be raised from waste or bog land undergoing improvement. The potato is largely cultivated in Great Britain and Ireland, and in many other countries from polar to sub-tropical regions, but the effects produced on the potato plant by spring and autumn frosts in this country show that a milder climate is its proper *habitat*.

Rye will grow on soils too poor and sandy for the production of any other cereal. It succeeds best in sandy soil, and more rye is grown in Belgium than barley and oats. It is not much cultivated in Great Britain or Ireland, for, as soon as the sandy soil on which it was raised becomes improved, other crops are sown. It is

sometimes mixed with wheat, and grown in the north of England. In the northern countries of Europe it is cultivated to a considerable extent, and it will ripen in cold regions where other cereals will not, barley excepted; however, it is produced in greatest perfection in districts where the other corn crops will ripen. In our country it will grow in elevated or mountainous districts, upwards of 1,200 feet above the level of the sea.

Mangold-wurzel succeeds much better in clay soils than turnips. It succeeds very well in the south and east of England, especially in the neighbourhood of London. In Scotland it does not succeed so well, the lower temperature there diminishing the yield and favouring the flowering of the plant in much the same way as a diminution of plant food. In the north-west of England and the west of Ireland it does not succeed well, it being more suited for a warmer and less moist climate; besides, it is unable to withstand frost, and has to be protected from its influence. It will yield a heavier crop than the turnip on reclaimed moor or bog land. The soil and climate of Jersey is well adapted for its cultivation. It is very free from insect attacks and other distempers.

The carrot succeeds best on a somewhat sandy light, or even a peaty soil, deeply cultivated, to allow the long roots free action in search of food. This plant is cultivated too in

greater extent in the Netherlands, France, and Germany than in Great Britain.

The parsnip is cultivated in much the same way as the carrot, and succeeds fairly in English gravelly or calcareous soils. It succeeds in clay too stiff for the carrot, but a rich free soil suits it best. It is cultivated in quantity in a few localities on the Continent, and especially on the deep sandy soil of the Channel Islands. Frost does not injure the parsnip, but has rather a contrary effect.

Cabbages succeed best on loamy deep land. They also succeed well on stiff clay and rich deep soils. The cabbage plant is in general cultivation throughout Europe and other parts of the world, in Asia, and North Africa, especially in the vicinity of the Mediterranean Sea. It is found in Wales and the south-west of England wild among the seacliffs, and as far north as Skye along the coast. Cabbages can be preserved from the effects of a severe winter by being placed slantingly, with the heads only visible.

Rape is cultivated to a considerable extent in the south of England on the oolite and chalk districts, but it succeeds best on rich alluvial and peaty soils. It also can be raised on reclaimed fens and bogs. It is grown on the alluvial and fenny districts in the east of England. It is generally cultivated in Continental countries, and it is there often ploughed into

the land for green manure. The roots of the rape have a beneficial effect on clay soils, loosening, and thereby rendering them more porous. It is often grown as a stolen crop between grain and roots.

The vetch succeeds best on calcareous soils, but can be grown on nearly all kinds of land. It is grown to a considerable extent as a stolen crop after corn and before roots. For its support it is usual to sow with it some of the grasses or cereals. It is chiefly confined to the temperate parts of the northern hemisphere.

Clover grows best on rich soils. If grown frequently on the same land it does not succeed, probably from a deficiency of some constituent of plant food. This is remedied by not raising this crop oftener than once in eight years on the same piece of land, and by liming. There are many varieties, of which the common red is the most valuable. The red variety succeeds well on loamy and marly soils. It is largely cultivated in Great Britain and Ireland. Clover is principally confined to temperate regions, and is especially abundant on the Continent of Europe and in America; it succeeds well on sandy loams, even when sown every alternate year on the same soil. It is a deep-rooted plant, and will grow on soils such as those in the south-east of England, where there is not enough moisture for other plants. As there is no opportunity of weeding while the land bears

this crop, it should be thoroughly cleaned previously. It restores fertility to soils that have been exhausted by cereal crops by fixing the ammonia and carbonic anhydride obtained by means of their leaves from the atmosphere in their stems and roots, which, on decomposing, leave these foods in the soil for plants that have not the same facility of obtaining these constituents from the air.

Italian rye-grass succeeds on loamy, calcareous, or alluvial soils, and very heavy crops are obtained from reclaimed bogs in the west of Ireland. It gives a greater yield in moist than dry climates, hence it is more productive in Ireland, Scotland, and the north and west than in the south-east of England.

Lucerne succeeds well on calcareous and rich soils, and fairly on land of medium quality. It does not succeed on stiff clays or moist land, but sandy soils when deep enough suit this plant. It is little cultivated in Ireland, not to any great extent in Scotland, and in England its culture is principally confined to the south, succeeding well in the deep brashy soils. It has been introduced into this country from the south of Europe. It is a common crop in the Channel Islands, and it is extensively cultivated in both North and South-America. Its roots penetrate the soil deeply so that it can resist great drought.

Sanfoin will grow on dry rocky land where

other similar crops will not. It succeeds well in the chalky soils of Hampshire, Berkshire, and the Cotswold hills. It has been grown so much in some districts that probably some of the food constituents have become exhausted, and another crop has to be raised in its stead, such as red clover. And when the clover has exhausted the soil, sanfoin will succeed. Its roots, like lucerne, clover, &c., strike deeply into the soil, so that it can readily obtain sufficient moisture. It is found in Europe and the temperate regions of Africa and Asia.

Flax is grown on a great variety of soils; but perhaps a deep friable loam suits this crop best. It can be produced on all arable lands with proper manuring. Neither very dry, light, nor wet adhesive clay lands are adapted for its cultivation, as it requires a medium soil—that is, cool without excess of moisture. The soil should be moderately firm, and the surface level, and reduced to a fine condition. It is a very exhausting crop, and does not succeed if grown too often on the same plot of land. It is more largely cultivated in Ireland, particularly Ulster, than in any other part of the United Kingdom. It is also produced on the Continent, particularly Belgium, and the southern shores of the Baltic Sea, as well as in North America and other countries.

Hops are largely grown in Kent, and to a less extent in Sussex, Hereford, Hampshire, Worces-

ter, Surrey, and a few other English counties. About 65 per cent. of the total quantity grown in England is produced in Kent, 15 in Sussex, 8 in Hereford, 4 in Hampshire, and a little over 3 per cent. each in Worcester and Surrey. There is a larger acreage under hops in Germany than the 72,000 acres in this country. Hops are also grown in New Zealand, Tasmania, Victoria, Canada, the United States, &c.

Hops require for their growth a very rich soil. The goldings require the most fertile —friable rich loams, and calcareous, rich, rocky land. This variety is largely grown in the east and middle of Kent. The white bines grow best on the same class of soils as the goldings. This variety is in favour at Farnham and Canterbury. The grape and Colegate, called clay hops, since they delight in heavy, clay soils, are grown in the wealds of Kent and Sussex. The variety termed Jones's will grow on inferior lands better than most other varieties.

The soil of Kent is peculiarly adapted for the hop culture, since it rests chiefly on chalk. In the north are the tertiary beds, including the London clay, and on the south-west is the greensand. In those parts of the country where the chalk meets the clay or sand the best hops are produced, as in the districts of Canterbury, Rochester, and Surrey, near Farnham, where there is a marly soil that contains phosphate of lime from the greensand. The phosphates are

of general occurrence between the gault and greensand of Kent and Surrey. The phosphates are very requisite and beneficial to the growth of hops, as proved by the increased yield after the use of superphosphates and guano after 1840.

The Hereford hops are grown on the red, rich, open, and friable soil produced from the old red sandstone. The Hampshire hops are produced by the stiff clays and chalk. The Worcester hops are grown in the valley of the Severn and Teme, the red soil being formed from the *débris* of the new red sandstone. The Nottingham hops grow on the stiff clays formed in the basin of the Trent from the *débris* of the new red sandstone, with the lias clay brought down by its tributaries, and any admixture from the magnesian limestone and coal measures.

CHAPTER VIII.

IRRIGATION.

IN a country like ours, in which springs exist and so much rain falls in varying quantities, frequently and irregularly, it is necessary for the successful growth of crops that this water should pass through and off the land, so that it may not become stagnant thereon, in which case the growth of crops is checked to a greater or less extent. In the case of bogs and marshy land, in which water is permanently stationary, the pores of the soil are filled by water, and the access of air, that is essential to plant growth, is prevented, humic and ulmic acids and other compounds being formed that preserve dead plants from being decomposed. Thus air is essential to the growth as well as the decomposition of plants. It is, therefore, necessary that air as well as water should permeate and pass onward through the soil. As it is essential to life that a fluid carrying air with it should traverse the bodies of animals and plants by means of a system of

arteries and veins, with their capillaries, so it is essential that water should pass onward and downward through the soil, giving up to the roots of plants in its progress the many kinds of food that it contains in solution, as well as the air always following water in motion. The more nearly the system of drains on any farm resembles the arterial and venous systems of vessels of animals, the more perfect the distribution of air and water containing food to the plant. The porosity of free soils allows the circulation of water without drainage, but clay soils being practically impervious to the passage of water naturally prevent rain or surface water from circulating to any extent through the soil without the assistance of drains. And when a main or arterial drain, with sub-mains and a regular system of furrow drains at proper distances apart and of sufficient depth, have been constructed, the water commences and continues to circulate the soil, giving up in its progress food to the roots of plants.

In animals the same fluid, the blood, continues in constant circulation, the loss or waste of that fluid being supplied by the food taken ; but on land the same water only passes through the soil once, fresh supplies being obtained from rains, springs, or by irrigation. As stated previously, the soil abstracts from the water percolating through it all the soluble nutritious constituents. The roots of plants also

take their food in the soluble form from water which must be present in the soil, as plants cannot take their food in the solid form. When the soil has become dry plants languish, although there is plenty of food in an unavailable form, but a shower of rain supplies water that percolates downwards, dissolving the soluble plant food, that is sucked in by the roots with avidity. The depth to which the roots of plants penetrate the soil in search of food is astonishing. Thus the roots of winter wheat have been traced to a depth of 7 feet, and clover roots to about half that depth. The roots of other plants extend to a greater or less depth, according to their nature and the drainage and quality of the soil. Similar beneficial effects are produced when water is made to circulate through the soil by irrigation, which is largely practised in China, India, Egypt, Italy, Spain, France, and to a limited extent in our own country. Rivers such as the Hoang-Ho, Yang-tsekiang, Ganges, Indus, Nile, Po, Adige, Tagus, Douro, &c., supply the means of irrigating the land. And in warmer countries than ours, where irrigation is not or cannot be effected, the soil is arid and barren. Even in moist climates like our own the beneficial effect of watering gardens in summer is apparent, and if it were only possible to extend to fields a garden irrigation, the result would be strikingly successful. A vast system of canals, with their distributing channels,

irrigate more than one million and a half acres of the Lombardian plain near the Po, increasing its fertility prodigiously. Egypt, but for the Nile, would be a waste and howling desert like the Sahara. The waters of this river yearly inundate the country, destroying the weeds and disintegrating the soil, and saturating it with water sufficient to bring crops of wheat, barley, beans, lentils, flax, cotton, &c., to maturity. About 50,000 machines, worked by oxen, are at present used for purposes of irrigation in the valley of the Nile, as summer or extra crops require a great deal of watering and cultivation. The seed sown after the inundation has subsided, towards the end of November, only requires the surface soil to be scratched by a bush and trodden down by the feet of animals.

In India there is an inspector-general of irrigation works, with secretaries in the provinces, so that canals and tanks are generally provided for supplying moisture to the soil, to counteract the unproductive tendencies of the dry seasons. Without irrigation famines in India would be far more frequent and terrible than they now are, and a large portion of the country that is now cultivated would be sterile.

A large portion of Spanish soil is arid and unproductive, except in those regions where irrigation is possible, and is practised when the high temperature will bring a succession of crops yearly to perfection, rivalling in luxuriance

the productions of any other country. In fact, during the occupation of the Moors, Granada was converted into a garden by means of irrigation works. The irrigation of the soil of the United Kingdom of Great Britain and Ireland from its comparative humidity and the fall of rain at frequent but irregular intervals during the whole year is not an absolute necessity as in many other countries, but nevertheless the productive power of the land is much increased by it. Thus a tract of meadow land near Edinburgh yields a rent of about £30 per acre when irrigated by sewage, the grass being cut three, four, or even five times yearly, producing sometimes nearly ten tons per acre. This system of irrigation is practised to a limited extent by individual farmers in Lancashire, Cheshire, Wales, Stafford, Nottingham, &c. The watering of pastures or meadows can be effected by catch-work or bed-work irrigation. In catch-work a drain termed a conductor, connected with the reservoir of water, is made along the highest side of the field; then a series of level gutters are made not more than 30 feet apart, with feeders crossing these from the conductor to the main drain formed along the lowest side of the field. This is the best method when the quantity of water available is limited. It is also the cheapest, costing about £4 per acre, and many consider it as effective as any other method. It can be applied to level or

sloping land, whereas bed-work irrigation can only be carried out where the land is level or nearly so. Beds are made some thirty or forty feet wide, gently sloping from one end of the meadow to the other. A conductor or drain connected with the irrigation water is made along the upper ends of the beds, and feeders are made from the conductor along the crown of each ridge, and the water after effecting the irrigation is carried into the main drain, made along the lower end of the beds, by small drains that are cut in the furrows. These small drains should gradually widen as they approach the main drain, but the conductor and feeders should taper towards their further ends so that there may be a continual overflow along their whole length, and that they may retard the flow of the water; and their inclination should be regulated according to the water supply. The cost of this method may be five or ten times that of the other.

There is another method of irrigation termed the subterranean. It is applicable for the drainage or irrigation of bogs, fens, or morasses. It consists of ditches all round the field, with drains not so deep at right angles across the land, so that the water from the ditches can rise in the cross drains to the level of the surface, or be drawn off by emptying the ditches by means of sluices.

In water-meadows, after the grass has been cut

or eaten down, the land may be kept under water for a few days, and then laid dry, and as winter approaches these meadows should again be submerged for about ten or twelve days at a time, but the period of submersion should be reduced until May, when regular irrigation should terminate. It is much better to thoroughly irrigate a part of the land than a larger area ineffectually when the supply of water is limited.

CHAPTER IX.

DRAINAGE.

THE object of the farmer in draining his land is not so much to get rid of the water in the soil as to effect its constant motion and percolation, so that fresh portions of water, containing new supplies of plant food, may be brought into contact with each separate root of the cultivated crop. When the water is stagnant the roots soon exhaust the soluble food contained in the enveloping water, and thus cannot obtain sufficient fresh supplies.

As far as drainage is concerned, soils may be divided into those readily permeable and those permeable with difficulty by water. The former class of soils have been termed free and the latter clay soils. Free soils may rest on a substratum preventing the level of the water from getting low enough to prevent capillarity, keeping the pores of the soil saturated up to or near the surface with water.

In this case the land is relieved from the sur-

face water by drains to a depth of 3, 3½, or 4 feet deep, at distances varying, according to the nature of the soil, from 20 to 50 feet. And when water presses upwards in the soil, deriving its supplies from a higher level, it is necessary to cut this water off by cross drains, and tapping the springs on Elkington's system. Clays also when wet from water derived from a higher source, should also be drained on the same principle, but clay soils wet from surface water can only be drained by a series of drains 7 or more feet apart, the distance increasing as the clay approaches more nearly a lighter or freer soil. With the main 4 feet 3 inches or 4 feet deep, and the minor drains 3 inches less, ordinary clays may have them 20 or 30 feet apart. Drains 3 feet deep or less in stiff clay soils will by capillarity fill the land with water to the surface, and in proportion as the depth of drains is increased above 3 feet, so is the depth of the surface soil free from permanent saturation increased. The depth of drains in clay soils should not, therefore, be less than 3 feet, so that the roots may not be constantly exposed to wetness. In cases where gravel occurs under clay, drains may be made at intervals of 100 or 130 feet, and at a depth of 6 feet.

The main drains in a field should be cut, as a general rule, in the line of quickest descent or greatest fall, and the furrow drains should

empty themselves into the main generally made 3 inches deeper. The furrow drains on opposite sides of the main should enter alternately, not opposite each other. Drains are cut with a set of spades of different widths, the widest for the top and the narrowest for the bottom, along which tiles or pipes of from 3 to 6 inches bore for main drains, and about 2 inches bore for furrows are laid. The continuity of these pipes is often preserved by means of collars of the same material as the pipes, having a larger bore so as to fit over the junction of the two. But this is not necessary, as it is usual to place over the points where the ends of the pipes meet some broken stones well wedged round so as to prevent the direction of the pipes being disturbed, and also to keep the spaces between the pipes open for the admission of water. In soft soil it is also advisable to place a slate under the junction of the ends of the pipes. Perhaps, however, by the use of collars the drains are rendered more permanent and effectual. Stones again, small enough to pass through a ring 2½ or 3 inches in diameter, may be used to lay along the bottom of the drain to a depth of 9 or 12 inches. Where stones are plentiful and well put in the drains they are quite as efficient as pipes, if not more so; they are also cheaper and more durable. When tiles or pipes are used there is no necessity to put a layer of stones or

pebbles over them, as the earth itself is more effectual in preventing the pipes choking than the stones; besides, as water enters a drain from below and not from above, there will be no danger in water carrying material downwards to choke the pipes, and, even if the water did pass downwards, clay or earth forms a far more efficient filter than rough stones. In draining boggy land it is a good plan to make the drain only about half the depth in the first instance, and then after the bulk of the water has been carried off and the soil become somewhat consolidated the drains are finished. In order to allow for a slope of about 45° it is necessary that the top be much wider than in the drainage of ordinary land. In some cases of soft soils semi-cylindrical tiles, termed muggs, are laid along the bottom of the drain on laths, but generally the pipes are sufficient. Sods also are used, and when carefully compressed into a circular form, and placed along the bottom of the drain with the grassy side downwards, they last a long time. Peat, faggots, straw, and other perishable articles are used sometimes to form a channel for water, but except in very special cases or for temporary drainage their use is not to be recommended. In the drainage of clay land the cracks or fissures produced by the drought of summer that are not entirely closed up afterwards render

this class of soil more susceptible to the circulation of water than it otherwise would be, for, while the clay is in a great degree impervious to water, these cracks allow it a ready passage into the drains. By the drainage of land the temperature of the soil and atmosphere is increased, and after heavy rains the water passes through the soil, giving up the fertilizing constituents it holds in solution instead of carrying off the finer particles and fertilizing matter by running away over the surface into water-courses. In drained land there is an alternate contraction and expansion that does not take place in that water-logged, which materially assists in pulverizing the soil. Less labour, and therefore less expense, is required for the cultivation of drained land, and the application of manure is much more effective. A greater variety of crops can be produced at an earlier period, of better quality and more abundant, when the soil is drained, and the health of animal life is considerably improved.

CHAPTER X.

IMPLEMENTS AND MACHINES.

THE ordinary tillage operations, such as ploughing, grubbing, harrowing, rolling, &c., produce many beneficial effects upon the soil. By ploughing, fresh portions of the soil are exposed to the disintegrating agency of the various meteorological influences, or are weathered. The soil is triturated or broken into smaller portions, that partially become soluble and available for plant food. The vegetation, including weeds, that may be on the surface is turned over, and plants having deep roots are cut through, so that their growth is checked and destroyed, decomposition breaking them up into plant food, as previously explained. These tillage operations also facilitate the passage of water through the soil upwards to the roots of plants by capillarity, and downwards to be carried away when in excess. This opening up of the soil by cultivation allows a freer access of air, inducing

the disintegration of the soil and the decomposition of organic matter. The principal object of cultivation is to pulverize the soil, in order to render it more soluble, and therefore more fertile. It is unnecessary to describe minutely the construction of a plough to farmers. It consists essentially of a beam, to which is fastened a coulter or knife blade, to cut the turf vertically, the share with a sharp point, and a horizontal projecting edge, to cut the sod horizontally from the subsoil, and the mould-board of turn-furrow, which, by the forward motion of the plough, gradually raises up and turns each slice over, exposing the under surface to the weather. One of the handles is a continuation of the beam, and the other is fastened to it by rods, as well as to the lower portion of the framework. At the opposite end the beam forms an upward curve, at the extremity of which is the bridle, to which the horses are attached by swing-trees and chains or traces. By means of the handles the ploughman can vary the width and depth of the sod. The larger the handles are, and the further the ploughman holds them from the point of resistance in the soil, the greater the leverage, and consequently the greater the power which he exerts over the instrument, especially in varying the depth of the slice, which can be done at will by the labourer with the swing plough, but with the wheel plough the depth is adjusted by lowering

or raising the rod to which the wheel is attached. In England wheel ploughs are common, and in Scotland swing ploughs, the latter requiring more skill to manage than the former. Trench ploughs are ordinary ploughs made larger and stronger, so as to penetrate the soil more deeply, and bring up a portion of the subsoil. The subsoil plough is divested of mould-boards, and consists of a strong beam with wheels attached to regulate the depth, and a bent tine or coulter to penetrate and loosen the under soil and facilitate drainage. The turn-wrest plough has two mould-boards, which are alternately brought into action, so that the furrows can all be turned in the same way, which in hilly districts prevents the natural tendency of the soil to work itself downwards.

The double mould-board ploughs are merely ordinary implements with a mould-board on each side, and are used for water furrowing, earthing up potatoes, drilling potatoes, turnips, &c.

And there are double and triple furrow ploughs, that are so arranged as to turn over two or three furrows instead of one. These implements effect a gain to the farmer, since a couple of horses will turn over two furrows instead of one, on light land especially, and even if three horses are required there is still a saving in labour and time. Land can now be, and is often, rapidly ploughed by steam power, by means

of a steam-engine placed on one of the headlands of the field, and directly opposite on the other headland an apparatus termed an anchor, or another steam engine, is placed, and a balanced plough is pulled to and fro by means of a wire rope that passes round the sheaves on the engine and anchor, and is attached to two drums on the plough, which consists of a framework of iron balanced upon two or more wheels, and to each side of this frame on the opposite halves are attached three, four, or more plough bodies with their coulters, so that three, four, or more furrows can be turned over simultaneously; and when either headland is reached one end of the beam is raised and the other depressed to plough in the opposite direction. By various mechanical arrangements the ploughman can wind up or let the rope out slack, or drop the winding drums out of gear in a moment, and adapt the plough bodies so as to take off slices of different breadths. Altogether the systems of Howard or Fowler leave little to be desired. By steam ploughing the soil is worked into better condition, and as on an average three roods can be turned over in an hour, much time is saved, enabling the farmer to take advantage of weather and conditions of soil that otherwise he could not do. By steam power deep cultivation is more practicable and especially advantageous in preparing the soil for green crops which are manured, as it is not always

advantageous to bring to the surface a few inches of fresh subsoil, containing little or no available plant food, by its previous exclusion from meteorological influences. Steam cultivation is more economical, better when the soil is heavy, the fields large, the stones few, the price of horses and the wages of farm labourers high. Although "crested" ploughing may be neater and more fashionable with farmers, yet the rectangular system, by which a greater surface of the soil is presented to the weather, is undoubtedly the best, and each sod lies firm or flat upon the adjacent sod, whereas by crested ploughing the angle of the sod rests on the other leaving a hollow under the point of contact.

The furrow slice in hay, stubble, or lea is generally 8 or 9 inches broad and 6 deep, but in preparing land for green crops the breadth is increased to 10 and the depth to 7 or 8 inches. In many parts of England stubble land is ploughed 10 inches deep, but thin soils require shallow ploughing.

However, the thickness and depth of the sod should vary with the nature of the soil and the crop to be produced. Roots require the soil to be deeply ploughed in the autumn, and sometimes a second ploughing in winter or early spring is advisable; but, as a rule, spring ploughing should be avoided, since it buries the fine soil produced by the frosts and weather,

and does not allow sufficient time for the further formation of fresh particles.

The grubber is an agricultural implement that has lately come into general use. It consists essentially of a cast or wrought-iron frame, carrying five, seven, or more teeth, curved forward in the form of a quadrant. The depth to which they penetrate the soil is regulated by raising or lowering the shank to which the wheel is attached. With teeth having a swan-neck curve at the top, weeds do not collect and choke the instrument, and broad shares or narrow points may be attached, the foremost used in autumn to clear the land of weeds and cut their roots, and the latter in spring. The grubber is generally used to stir land previously ploughed, to bring clods to the surface to be broken, to clear from weeds, &c., but sometimes it is used to tear up stubble and clover fields before ploughing. The teeth can be easily lifted out of the ground to clear from weeds or obstructing clods. As the teeth penetrate to a depth of 5, 6, or more inches, and do not overturn the soil, nor bury the fine mould, nor raise indurated clods, nor promote evaporation, the grubber is well adapted for spring cultivation. It is stated that the grubber does not deal effectively with certain weeds, such as tap roots, thistles, colt's foot, docks, &c., unless drawn by steam. Two horses drawing five teeth will grub 3 acres a day, but with a larger number of teeth, three, four, or more horses, or steam power is required.

The harrow, like the plough, is a very ancient agricultural implement. The construction of each was equally rude, the original form of the plough being a sharp-pointed stick, while that of the harrow was a branch or bush. Afterwards wood was made into a frame and wooden teeth inserted to scratch the ground, and, as the tines or teeth wore out rapidly, iron was substituted. A square, rectangular, or rhombic wooden frame with iron tines is now much used for light soils; but for heavy land an implement made entirely of iron is more serviceable and more used. An ordinary harrow covering 9 feet consists of two parts, hinged at two points, each part consisting of four bars with four cross-bars made of ash, each bar containing five iron tines, or altogether forty. The frames are rhomboidal in form, and so arranged that forty equidistant tracks are made by the teeth, except when the outside of the bars by the pressure of clods causes the implement to oscillate. Howard ingeniously obviates this difficulty by means of his metal zigzag harrow, which will give 12 acres a single even stroke in the day.

The drill harrow is used to loosen the ground and tear up weeds between the rows of root crops. The saddle harrow is used to run over bean and potato plants, before they have reached the surface. The brake breaks down hard or rough land, and the chain harrow, con-

sisting of a mass of iron rings, is useful in separating weeds from attached earth, for covering in grass seeds, for rendering the soil fine, and to brush in farmyard manure applied to grass lands. Seed harrows level and pulverize the surface and follow the drill, covering up the seed —not grass seed; that requires lighter harrows. The heavy drag harrow turns over the surface soil, exposing fresh portions.

A roller consists of a cylinder of wood, stone, or metal, placed in a frame, so that it may be drawn over land. The weight as well as the material vary according to circumstances. The light, solid, wooden rollers, the ends bound with iron or wholly covered with sheet iron, smooth the surface for fine seeds. A cylinder of stone drawn from its axis without frame is the simplest form. Metal rollers are hollow, usually made of cast-iron, and sometimes of wrought-iron. A roller of about 12 cwt. is sufficient for light land, but for heavy soils one of 17 cwt. or above is requisite. For ordinary purposes they should be about 5 feet long and 2 feet in diameter, and divided into two or three segments, to facilitate the turning at the headlands. Rollers of only 10 or 12 inches in diameter are not uncommon. They require a greater expenditure of power to drag them along than those of equal weight but greater diameter, since the force of the horse is exerted with a smaller everage; besides, they sink more into hollows.

Stones and other weights are sometimes attached to the frame to increase the weight; this additional weight presses on the axle, causing friction that requires more than a proportionate amount of force to overcome. As the weight of a roller requires to be varied, especially when there is only one on the farm, it is more economical of labour to increase the weight by introducing water into the cylinder. The plain iron roller is principally used for grass land. The Cambridge roller consists of a cylinder composed of a number of discs, the alternate ones varying a few inches in diameter, so that the larger ones rise above the other with a jerk, that renders this form of roller self-cleaning when others would be clogged.

The Crosskill roller, or clodcrusher, consists of a cylinder composed of separate discs, of about 3 inches thick and 2½ feet in diameter, forming a roller about 6 feet long and weighing upwards of 1½ ton. This form of roller is often essential to the preparation of heavy clay soils for root crops. The alternate discs may be of different diameters from the others. This roller was intended to grind clods to powder, and form a fine tilth from intractable clay soils, but the Crosskill and Cambridge forms are more useful in compressing light soils for wheat, or this and other crops for wireworm, or winter-sown crops in spring. However, the pulverization of clay clods does not appear to be a paying process.

CHAPTER XI.

FARM BUILDINGS.

FARM BUILDINGS include the farmer's house, with the various outhouses for stock, crop, implements, &c., attached, adapted to the requirements of the farm, with the cottages for the labourers, the whole being usually called the homestead or steading.

There should, as nearly as possible, be a perfect adaptation of each outhouse to attain the objects for which it was constructed, together with a study of economy of labour and time in going from one outhouse to another. With this object in view, the dairy should be convenient to the farmhouse; the houses in which food is consumed should be near to that in which it is prepared, and the latter convenient to that in which the food is stored.

The stable and cow-houses should be convenient to the straw-barn, the latter near to the barn, and the manure heap should be convenient to those outhouses in which it is formed. The farmer should never erect a steading himself, as it is a very expensive

matter; besides, if on entering a farm his attention is engrossed with the building of premises, the culture of the land will be neglected to a greater or less extent. The landlord should therefore be at the expense of building a homestead, which the farmer should keep in repair.

The outlay should be such as might reasonably be charged on the land with interest not to exceed 4 per cent. The outlay for farm buildings varies inversely with the size of the farm, 500 acres costing about £10 per acre, including dwelling-house, &c., while 100 acres will cost about double that amount; however, the estimate or outlay for the same accommodation varies considerably, being in some cases double what it is in others.

In consideration of this initial expense of the landlord, the tenant has to pay a higher rent for the land. The steading forms, in fact, a portion of the fixed machinery of the farm which the farmer does not usually buy, but rents from the landlord. The implements, machines, stock, and all other requisites for the cultivation of the farm are provided by the farmer himself. The farmhouses, especially when well adapted to the requirements of the farm, are generally well worth all that is paid for them, but if they are unsuitable and not adapted to the exigencies of the farm, they are usually dear at any price.

Considerable attention should be paid to the warmth and comfort of the stock, consistent

with proper ventilation, for it is almost impossible to make animals too snug for health and growth. When animals are cold they are restless, and more food is required to keep up the animal heat.

In the erection of farm-buildings the site, the drainage, the water supply, free air, shelter, dryness, and aspect should be considered. Covered farmyards, having all the various outhouses under one roof, are increasing, because it would appear that they are better, and can be erected at a less cost, than any other system of steading. And in the construction of these, as well as other styles of homesteads, a uniform plan should not be adopted by landlords, but they should be erected entirely according to the exigencies of the farm. When the outhouses are all under one roof it becomes more essential to attend to the proper ventilation, since any injurious effluvia or bad air engendered in any part will soon permeate the whole. To prevent any foulness the different outhouses should be kept scrupulously clean, then, with the proper ventilation with which these covered steadings are supplied, an almost perfect current of fresh air may be kept up by means of ventilating bricks and windows. The eaves are carried high enough so as to afford an opening all through the length of the steading for currents of air to and fro, the amount of air being regulated by louvre boarding or shutters. And

ventilating shafts may be made under the mangers with occasional air-brick openings.

If the farmer did not originally build the steading, he must subordinate his convenience or taste to the present arrangement of the various offices of the farm unless he has the necessary capital to pull down and re-erect; but, as it is stated that fools build houses for wise men to live in, it is much better for him to act the part of the wise man, and endeavour to be satisfied with the existing premises. But if he or the landlord must build new premises, some knowledge is required to select the most healthy and convenient spot on the farm. If the ground of the farm is level, and the soil pretty much alike, the premises should be placed near the centre for obvious reasons; but if the land is hilly, he may build his premises on the highest or lowest part of the land, as near the centre as possible, according to the healthiness of the situation. It is not of much consequence whether the premises are high or low, as the carting up the hill and down will be much alike. But the drainage is of primary importance, coupled with the salubrity of the situation. A high situation may be chosen if dry, and a low situation if a good drainage can be made. Too much foliage should be avoided, for the collection of decayed leaves near the farmhouse poisons the air to a certain extent, producing prostration of the

body and mind, causing dyspepsia and headache. In some English counties which might be specified the air is saturated with moisture and the exhalations from vegetable life; in others the air is bracing, and the foliage near the farmstead is beneficial rather than the reverse. A gravelly subsoil is always desirable in high situations and in low situations when an effective drainage can be made, but a gravel bed on the latter, surrounded by clay that keeps it as wet as a sponge, is a most undesirable position for the farmyard. The primary rocks, sandstone, limestone, and chalk, form a good subsoil for building upon. A south-eastern aspect of the house should be preferred, and then a south, south-west, west, and east, but on no account a northern aspect.

According to the requirements of the farm so will the arrangement and the number of the outhouses differ. The highest buildings should be so placed as to afford shelter from prevailing winds. It is often desirable to arrange the outhouses so that they should have a common entrance. The buildings may be arranged in the form of a parallelogram, with houses and sheds along three sides, the fourth side opening in a southerly direction. The barns may be arranged together at the middle of the north side of the parallelogram, and continuously with these to the right and left, and also at right angles should be the houses for

the animals requiring straw. And in the centre, in front of the barns and between the stock-houses, at right angles to the barns, will be the most suitable place for the working covert. The spaces between the cattle houses at right angles to each other will form the cattle courts. The houses on the extreme east and west sides of the parallelogram removed from the barns will be allotted to those animals not requiring straw, and the houses forming portions of the east and west ends of the south side of the parallelogram may be allotted to implements, carts, &c.

By placing the barns at right angles to each other to the right or left of the middle or working court, on the north side of the parallelogram, and the other houses relatively, arrangements can be made to suit the circumstances of each case.

On either side of the straw-barn, houses may be built for roots, mixing and pulping, and the engine and boiler, with space for coals. On the floor over the roots, corn, cake, meal, &c., may be stored ; the chaff-cutting floor may be placed over the mixing house, with the granary over the winnowing floor. The main shaft from the engine house may pass through the food apartments and steaming house, to do any work that may be required. A plan for a steading may be arranged with the stables and piggeries to the east and west of the rectangular farmyard, with the cattle stalls or byres on each side of a

central feeding passage running north and south, being cut at right angles by another passage running east and west, dividing the inner space into four yards, the front two being covered and open to the south, while the back ones will afford space for two dung sheds (with tanks for liquid manure) convenient to the byres, stables, and piggeries. The north side of the steading might contain, commencing at the west end and proceeding eastward, the hospital with farmers' stores, bull-box, coal, boiler, and engine house, straw-barn with thrashing barn jutting out northward, the root house, mixing, and pulping house, with granary, chaff-cutting floor, and cake, meal, &c., over barn, then roots, and mixing house. Then a wide passage to stackyard, with accommodation successively to the east for artificial manure, implements, waggons, and shops for smith and carpenter. The fowls' house may be situated to the south of the piggeries, the calves' house continuous with and to the south of the cattle stalls, and continuous with and to the south of the stables may be erected a loose box, hay store, and the nag stable, with harness- and coach-house convenient to the farmer's house, situated to the south-east of the steading. The house may contain a living-room, a pantry, stores, and office on ground floor looking towards the steading, with parlour and kitchen having a southerly aspect, and bed and other

rooms above. A large yard containing dust bin, privy, &c., to the west, with larder, scullery, washhouse, and coals to the south; and, if dairy accommodation is required, premises may be erected to the west of the yard and wash-house, containing cheese-room continuous with the latter, and engine-room with room for clean utensils and washing to the north, leading into the milk-room, to the south of which would be the churning and the butter-room. By this arrangement the dairy would be close to and immediately to the south of the cattle stalls, and communicating with the kitchen as well.

The dairy is usually convenient to the kitchen, which very often forms the working-room, to which a milk-room should be attached, and a store-room when there is one; and the houses of the milk cows should be arranged near to the dairy if possible.

When pigs and poultry are kept proper accommodation should be made for them. The best position for the manure heap requires consideration, and should be convenient to the houses in which the stock are kept. There should also be underground drains from the byres, stables, pig-styes, and shelter yards to convey the urine to one or more tanks, so that this valuable liquid manure may be pumped from time to time over the manure heap, or otherwise utilized.

The erection of farm buildings suitable to a

farm requires much previous consideration, so that the resultant steading may prove to be well adapted to the requirements of the farm. The relative merits of various plans should be closely scrutinized, and that adopted which is considered to be the best, provided the cost is not too great. The landlord or other party about to erect a homestead should employ some architect or builder in whom he can repose confidence, otherwise he will require to make himself master of the details of plan, cost of labour and materials. As the architect's remuneration is usually about 5 per cent. of the total cost, it is to his interest to make the cost as high as possible; besides, in the erection of small steadings, say a few at £1,000, his fee—£50 per £1,000—does not always pay him for the drawing of plan and seeing that the work is properly executed. He may therefore neglect his duty of supervision, or he may require an extra remuneration from the builder, which means extra cost on the landlord's outlay. By the employment of a clerk of the works at a salary of a few pounds weekly, to constantly supervise the erections, there is little chance for the builder to scamp the work or use bad materials, whereas an architect taking an occasional look, say, once a fortnight, cannot detect any building frauds that may be practised. The constant care of the landlord or his agent in the erection of farm buildings should be to keep

the expenses down, for builders are generally liable to increase the cost by charging according to the system of measure and value, which usually means in rural districts an increase of perhaps 20 per cent. on the price of materials, and probably double that percentage on labour. In most cases an ordinary builder will be able to erect the needful premises when properly supervised, but the system of contract almost necessitates the employment of an architect to approve.

An incoming tenant should be careful to thoroughly examine the state of the premises, so that he may take possession with his eyes open, and an outgoing tenant should be cautious not to leave the landlord any room for the exercise of his just rights in regard to dilapidations, &c. The incoming tenant often takes possession at Martinmas, Lady Day or Whitsuntide, by virtue of a lease or otherwise. In many parts of England the farmers hold their land from year to year, depending upon the good faith and fairness of their landlords. This yearly system as a rule has worked well, due as much to the landlords as the tenants. However, the Scotch system of granting leases for nineteen years is now becoming more common in England. There are many clauses in these leases some of which are of an obligatory or a prohibitory character. Tenants are often prevented from selling turnips or straw. In other

cases they are allowed to sell the straw, but they must replace it by suitable manure. Then there are cropping clauses which do not allow the too frequent growth of particular crops—for instance, the growth of two crops of grain in succession. These prohibitory clauses are often injurious to the interests of the tenant, inasmuch as in good arable land barley will not hurt after wheat, and pease may be grown if not repeated more than once on the same piece of land during a nineteen years' lease, which would allow not more than one-nineteenth of the arable land under that crop in any one year. The clauses of the lease should be definite and precise, so that there should be no room for any misunderstanding that may lead to disagreement, ill-feeling, or litigation. The clauses of a lease will vary for every district, inasmuch as the soils vary, causing a variation of the crops, a variation in the quantity of stock kept, and in the whole economy of farming. In grazing districts, short leases of about eight or ten years, susceptible of renewal, answer very well, but a lease of cultivated land for less than nineteen years does not allow the tenant sufficient time to recoup himself for money spent in improvements and otherwise. The landlord should transfer the farm to the tenant in proper order, and the latter should possess sufficient capital to cultivate it advantageously.

CHAPTER XII.

FARMYARD MANURE.

ON many soils a succession of crops may be produced without any apparent diminution in the yield. In some cases this practice has been continued more than a century. A remarkably fertile soil in Moravia yielded upwards of 150 successive crops of corn. And virgin soils in the United States of America yield a great many crops without any application of manure. But no matter how long this process may be continued the land will require manuring eventually, for it is always found that the produce, instead of increasing, diminishes the longer manure is withheld, maximum crops being produced only by the proper cultivation of good land abundantly manured.

The ordinary crops grown in this country abstract from the soil certain constituents that exist in a minimum state, and certain manures, such as farmyard manure, superphosphates,

guano, &c., have to be applied to the land to maintain its fertility.

Of these fertilizers farmyard manure is the most perfect, since it contains all the mineral substances found in plants, together with a large proportion of combustible matter that is, after application to the soil, decomposed into carbonic anhydride, water, and ammonia. It is formed of the liquid and solid excrements of cows, horses, pigs, sheep, &c., mixed with the straw that is used as litter, and occasionally with mould, turf, ashes, leaves, and all kinds of house refuse of an organic nature.

The manure heap should be formed on level ground, with a paved or clay foundation that will not allow the escape of the valuable constituents. If put into a hollow it becomes water-logged with rain, and if placed on sloping ground fluid containing the most valuable constituents will run away and be wasted. It is advantageous to place earth round about the manure heap so as to absorb any liquid that may ooze out from it, and when this earth becomes saturated with moisture it should be shovelled to the top, and a fresh quantity put round about it as before. In order to avoid extra labour the heap should be convenient to the byre, stable, and piggery, and as far removed as possible from the farmhouse and dairy. It should be situated to the north of the farmyard, so

that all disagreeable and unhealthy effluvia might be blown away from the farm buildings. It is a very slovenly and bad plan to allow the manure to lie about in small heaps, as its value becomes deteriorated from the escape of its volatile constituents. The presence of a certain temperature with air and moisture is requisite for the decomposition of the manure. If the farmer finds that the heap is decomposing too rapidly it should not be turned over but compressed in order to exclude the air. But the heap is generally turned over once and sometimes twice in order to admit air to promote decomposition and render the manure more uniform in quality.

The larger the heap the less it loses by the influence of sun, rain, and air. In summer it is a good plan to cover it with a layer of mould or peat in order to absorb ammonia and other volatile or soluble products of decomposition. Others again advocate the covering of the manure heap by a roof to prevent loss by rain. During the winter, as the temperature is low, there is little or no decomposition, but the heat of summer favours the breaking up and decomposition of the litter in the heap, but it is not advisable to allow the temperature to rise above 30° C. At a moderate temperature, with sufficient air and moisture, humic and ulmic acids are formed, and these form, with the ammonia

which is simultaneously produced, ammonic humate and ulmate, which prevent the dissipation of the ammonia. Ferrous sulphate may be added to a manure heap to prevent the dissipation of the ammonia by the formation of ammonic sulphate and ferrous carbonate, both of which are available plant foods.

The manure of cows and pigs is of a cold, pasty consistency, and resists decomposition for a longer time than that of the sheep and the horse, both of which are drier and break up more readily in the soil. One cow, house-fed during the year, will produce upwards of 10 tons of manure, or about sufficient for half an acre of potatoes. The value of manure depends on the kind of animal producing it, and also upon the condition of the animal, whether fat or lean, or whether with young or giving milk, and also upon age. Young or growing animals, lean ones, and those carrying young or giving milk abstract more nutriment from their food, and hence they do not produce such a valuable manure as the old or fat. The value of manure depends to some extent on the manner in which the animals are housed, and also upon the quantity of litter supplied. When animals are kept in boxes there is a thorough mixture of the litter and dung, that does not take place when they are kept in stalls, hence box is more valuable than stall manure. When beasts are kept in sheds, with yards attached,

the manure becomes depreciated in quality from excess of rain and litter. The value of manure depends in a great measure on the food of the animal; for when fed on straw and turnips, mangel, or carrots, the dung produced has only one-third the value of that yielded from the consumption of hay or oats, and one-sixth of the value of that from linseed, pease or beans. Decorticated cotton seed cake yields a manure twelve, and rape and linseed cake eight times, more valuable than that from straw and turnips.

During winter, when the weather is dry and frosty, when no agricultural work is going on, is a good time to cart the manure from the farmyard to a convenient spot in the field where it is required. The heap should be formed on a bottom of weeds or other vegetable rubbish, peat, or on a retentive clay soil, so that the liquid manure may be absorbed by the weeds or peat, or retained by the clay. When carted out early in the winter, the load is emptied, and the cart taken over the heap each time, so that it may be compressed and the air excluded; but when taken out later in the winter it is thrown up in a loose state so that decomposition may be promoted. The heaps should not be raised higher than about 5 feet as the temperature in the centre might rise too high.

Fresh manure contains about 4 per cent. of

insoluble inorganic matter, while that kept for five or six months contains about 6, there being under 2 of phosphoric acid in the insoluble phosphates. There is upwards of 25 per cent. of insoluble organic matter in fresh, while there is only about half that amount in the other, containing about .5 and .3 per cent. of nitrogen. The total quantity of soluble inorganic constituents is about 1.5 in each, containing about .3 and .4 respectively of calcic phosphate. Fresh contains about 2.5, and old manure about 3.7 per cent. of soluble organic matter, having about .15 of nitrogen in the former and twice that amount in the latter case. The fresh contains about 65 and the old about 75 per cent. of water. In the insoluble inorganic constituents there is found soda, sulphuric acid, potash, magnesia, oxides of iron and alumina, phosphates, carbonic anhydride, lime, and silica, in the proportion of 1, 3, 5, 7, 10, 19, 24, 56, and 70 respectively in fresh manure. The same inorganic constituents, excepting the oxides of iron and alumina, are found soluble in fresh manure as the numbers 1, 1, 11, $\frac{1}{5}$, 6, 4, 1, and 5 respectively.

The urine of the domestic animals should not be allowed to run away or be wasted, as it contains very valuable constituents.

A portion of the urine is absorbed by the litter, and the remainder should be allowed to run into a receptacle, from which it should be

pumped over the manure heap, and if there is an excess it should be applied to the nearest field of grass. When added to the manure it promotes its decomposition. When urine is allowed to stand for some time it becomes more acid, and after a few days putrefaction begins by the decomposition of the urea into ammonic carbonate. This decomposition sometimes takes place before the urine is voided, the mucus contained in it acting as a ferment.

Urine contains about 95.7 per cent. of water, about 2.3 of organic matter (urea 1.4, and kreatine, kreatinine, uric acid, hippuric acid, &c.), and about 1.3 of inorganic constituents—consisting of sodic chloride .7, phosphoric anhydride .2, potash .19, sulphuric anhydride .17, lime .02, magnesia .01, soda .005, &c.

The urine of cattle contains a large quantity of urea, with hippuric acid and a very small amount of uric acid and phosphates. In order to prevent the escape of the ammonic carbonate it is a good plan to add to the urine about twice its volume of water.

Urea $CO(NH_2)_2$ is the most valuable constituent of urine, as it contains two atoms of nitrogen, which on decomposition form ammonia.

All sorts of animal and vegetable refuse and rubbish should be collected for manure.

Earth should be added to animal refuse to prevent the escape of ammonia, and lime is

generally added to all the vegetable rubbish of the farm to the extent of one-fifth of the bulk. Composts are sometimes made by pouring all kitchen refuse on heaps of clay. By this means the constituents of the clay are rendered available as plant food.

When there is a rotation of crops, farmyard manure is applied to roots and green crops only, so that when there is a four-course system the soil is manured only once every four years. And if there is sufficient it is a very good plan to give the clover-seed a dressing of farmyard manure in early spring, which much improves the value of the clover, as well as the succeeding crop of wheat. Manure is applied to potatoes in March, mangel in April, and turnips in May, June, or July, and to other crops, as cabbages and vetches, in September, &c. In summer the manure should be ploughed in at once. Green crop manuring is the ploughing in of crops of mustard, vetches, &c., so as to render the mineral constituents of the soil that were contained in these plants more easily available for those following; besides in this way a large quantity of nitrogenous organic matter is added to the soil, that produces a marked effect on future crops. But farmers can seldom afford green manuring, as dairy produce and meat are so dear; it pays them better to pass the green crops through cattle, and thus obtain both milk and flesh.

If all the food produced in this country was consumed on the spot and the disorganized constituents were applied to the land from which the food was yielded, the soil would remain fertile for a longer period than it now does; but as most of the food consumed in towns forms sewage, and about three-fourths of the disorganized constituents are not returned to the soil, pass away into rivers, &c., it becomes necessary to import and apply to the soil in this country various kinds of manures according to the requirements of each case. We should not require to import foreign manures if all the disorganized constituents of home and foreign food were applied to the soil in order to produce a maximum degree of fertility. The process of allowing the sewage to be wasted in the present reckless manner is unwise; besides, the rivers into which it flows become little better than open sewers. The present system in towns by the addition of large quantities of water in order to facilitate the removal of manurial matter through pipes, renders sewage a very dilute aqueous mixture, or solution of the disorganized constituents of food. It has been calculated that in 10 tons of sewage there are $4\frac{1}{5}$ lbs. of nitrogen, sodic salts, potassic salts, and phosphoric acid in solution, composed of 1.7, 1.6, .5, and .4 lb. respectively, and that there is $1\frac{9}{10}$ lb. of constituents suspended, consisting of

1.4, .3 and .2 lb. of organic compounds, nitrogen and calcic phosphate respectively.

As nitrogen, sodic salts, potassic salts, phosphoric acid, organic matter, and insoluble calcic phosphate are worth £70, 1s. 10d., £20, £40, 10d., and 8s. respectively per ton, the value of all these constituents taken together in ten tons of sewage would not be worth more than 1s. 6d. At this small estimate of 1⅗d. per ton, it has been calculated that the annual value of the sewage of London would be worth about £1,773,333, and at 1d. per ton it would be worth upwards of £1,000,000. The average value of the excreta of a unit of the population of a town varies between 5s. and 11s., so that in large towns the annual value of the sewage is considerable. As a ton of town sewage may be worth only ½d. or as much as 2½d. per ton, it is necessary that the cost of its application should be very small indeed, otherwise the cost of its removal would be greater than the benefit derived from its application to the soil. And as a loss would be incurred in many cases by its application to land, it has been carried off into rivers and allowed to go to waste. In other cases, as at Croydon and Edinburgh, the sewage is applied to the adjacent land by gravitation economically. Several years ago attempts were made to precipitate by milk of lime most of the valuable constituents of the sewage, but as the result was unsatisfactory and unremunerative, this method has been abandoned.

A mixture of alum, blood, charcoal, clay, manganese (oxide), &c., and also a solution of aluminic phosphate have been applied to sewage with no decided success. However, it is probable that in the course of time some improved method will be discovered by which sewage or its valuable constituents will be utilized to a far greater extent than at present.

The milk obtained from sewaged grass has been found to be treble that from the unsewaged. Sewage appears to produce the greatest effect on Italian rye-grass, as by its application about seven crops may be obtained from even poor soils. It is also beneficially applied for cabbages, mangel, potatoes, rhubarb, beets, &c. Its application to beet increases the percentage of sugar from 9 to 13 per cent. The quantity applied per acre varies from about 500 tons to about forty times that amount.

CHAPTER XIII.

ARTIFICIAL MANURE.

THE great bulk of plants consists of combustible or volatile matter, the dried plant containing about 3 per cent. of ash. The mineral matter is derived from the soil, and the volatile from the air as well. The combustible constituents of the soil must be decomposed into carbonic anhydride, ammonia and water before they can be used as plant food. The combustible matter may be derived entirely from the air as in the case of many wild plants, but farmers cannot produce good crops unless there is a certain amount of this matter in the land, except in the case of lava soils.

To keep up its fertility the farmer should return to the land all the mineral constituents sold off it. When all the produce is sold and not returned, as in the case of market gardens, &c., more manure should be applied than in cases where a portion of the produce is returned in the form of farmyard manure. The

application of potash to light lands often increases its fertility, since it is liable to be present in a minimum.

The application of calcic phosphate restores the fertility of land in which that constituent either had disappeared or had become deficient.

In most soils silica is practically inexhaustible, and so is potash in clay.

Farmyard manure bears the same relation to plant as milk does to animal food. When applied to land deficient in phosphate of lime it acts as a fertilizer by its phosphate of lime, and when applied to land deficient in soda, sulphuric acid, potash, magnesia, carbonic anhydride or lime, it produces fertility supplying one or more of the defective constituents, and not by the supply of any of these in excess. Hence, if any soil is known to be deficient in only one constituent, its fertility may be restored by the application of that constituent as an artificial manure, without farmyard manure, since the latter would merely add to the compounds already in excess without sufficiently increasing the defective ones. As phosphates generally exist in a minimum state in the soil, the application of artificial manures containing them is common. Bones containing phosphates have been applied in various forms. In the whole state they remain in the soil for many years before decom-

position takes place, hence they are ground in small pieces by a mill, when they are found to be more active as fertilizing agents. Even in this state their action is slow and well adapted for grazing land. The action may be hastened by subjecting them to high pressure steam, or by mixing ground bones with earth and saturating with liquid manure, when after a few weeks' fermentation they become softened. The bones of the higher classes of vertebrata possess the same general properties. When dried at 100°. C. until they cease to lose weight, it is found that nearly one-third of their weight consists of organic matter, the remaining two-thirds consisting chiefly of calcic and magnesic phosphates and calcic carbonate. Fresh bones contain nearly 50 per cent. of water. The organic matter is combustible, and consists chiefly of gelatine. By boiling, the external portion of the gelatine and most of the fatty constituents are removed. An average analysis of dry bones contains 64 of tricalcic phosphate, 28 of organic matter, 4 of calcic carbonate, 2 of magnesic phosphate, 1 of alkaline chlorides and sulphides, and 1 per cent. of insoluble matter.

If we put an ordinary beef bone, after being weighed, into the fire, and leave it there until it becomes white in colour, then take it out and re-weigh it, we shall find that, if it originally weighed 3 lbs., now it only weighs 2 lbs., 1 lb.

of organic matter or gelatine having been consumed.

When a bone, freed from fat and the outer fibrous layer, is exposed to the action of hydrochloric acid diluted with seven parts of water, effervescence will take place, owing to the presence of calcic carbonate in it, and when left in this solution for a few days its salts will be dissolved, and ossein will remain after repeated soakings with distilled water. When dried, it will assume the appearance of horn, and when boiled for a few hours it will be dissolved, and on cooling it gelatinizes, forming a weak glue. The hydrochloric acid solution deposits the phosphates on neutralization by ammonia, and on adding ammonic oxalate to the filtrate, the calcium is precipitated as calcic oxalate. The H Cl solution forms a valuable manure. As stated above, by ordinary boiling, grease or fat and a little gelatine are removed, but if the bones are exposed in water to a temperature of 150° C. in a Papin's digester, the whole of the gelatine is dissolved, leaving the earthy matters in a disintegrated form. When bone is heated for a few hours in a closed vessel it assumes a black colour, and is called bone black or animal charcoal, containing the phosphates with carbon diffused in a finely divided state. In this distillation tarry and volatile matters pass over, accompanied with ammonic carbonate, &c.

The amount of nitrogen in bones varies from 2½ to a little over 3½ per cent.

Their composition varies with the age of the animal, and also with the part of the body to which they belong.

The bones of the ox furnish a more valuable manure than those of the sheep, and the latter are more valuable than those of horses. The bones of fishes do not contain so much phosphate as the higher animals.

Bones when ground to powder supply the soil with ammonia, lime, and phosphoric acid, and when burnt they furnish the two latter constituents only. As fat is useless when applied to land it should be removed by boiling, and the resulting liquid, since it contains a valuable amount of nitrogen, should be poured over the manure heap.

The bones of commerce are frequently adulterated with coprolites, gypsum, marl and sand, and bone dust may be adulterated to the extent of 50 per cent. Of course it is not so easy to adulterate whole bones. We import into this country a considerable quantity of bone ash, especially from South America. This ash contains about 70 per cent. of tricalcic phosphate, and also calcic carbonate, alkaline salts, carbon, insoluble earthy matter and moisture. It is rarely applied to land, but is used in the manufacture of artificial manures. The tricalcic phosphate is insoluble in water,

but is sparingly soluble in water containing sodic or ammonic salts or carbonic anhydride. To render it soluble in water it is subjected to the action of sulphuric acid. The tricalcic phosphate $P_2O_2Cao''_3$ contains about 48.75 of phosphoric acid and 51.25 of lime. The soluble phosphate can be prepared cheapest from coprolites.

Of all the constituents of soils phosphate of lime is most liable to become deficient. In ordinary and light land it exists in very small quantity. It is therefore better adapted to light than heavy soils. It is principally applied to root crops, and an application of 2 cwt. per acre to poor light land increases the yield of turnips very considerably.

The value of animal and vegetable manures is due to a great extent to the nitrogen present in such substances as albumen, caseine, gluten, legumen, and fibrine. These substances on decomposition are converted into ammonia, and finally nitric acid, the former on coming in contact with acids forms ammonic carbonate, phosphate, sulphate, or other salts, and the latter forms with bases potassic, calcic, sodic, &c., nitrates.

Potassic nitrate occurs in considerable quantities in the soils of Spain, Arabia, Persia, India, &c., and is present in almost all land, though it may be in only small quantities. The soils in which it occurs in large quantities are treated

with water, which dissolves the potassic nitrate together with sodic chlorides and organic matter. This solution is allowed to clear by standing, and is boiled down. By dissolving the crude nitrate in hot water it is separated from the $NaCl$ in a great measure. The solution, after separation from the residue, is boiled with glue, when the organic matter becomes coagulated, and is skimmed from the surface. Potassic nitrate is obtained from sodic nitrate (Chili saltpetre). On the Continent this compound is formed artificially by decomposing organic matter containing nitrogen. Potassic salts have been rendered much cheaper by the discovery of kainit at Stassfurt, in Prussia. These salts can be bought for £4 per ton. Kainit consists of $NaCl$ 30.4, K_2SO_4 24.4, $MgCl_2$ 14.3, $MgSO_4$ 13.2, water of combination 10.9, moisture 3.4, $CaSO_4$ 2.7, and insoluble silicious matter .7. Potatoes are benefited by the application of potassic salts, which also stimulate the growth of leguminous plants. Calcium nitrate is produced by the decomposition of nitrogenous organic matter in presence of lime.

Sodic nitrate (Chili saltpetre) is the most valuable of the nitrates. It is found in large quantities in South America as stated above. The commercial substance contains about 17 per cent. of nitrogen, and the dry salt contains about 63 of nitric acid, which is expelled at a red heat. The genuine article should

lose about two-thirds of its weight when ignited. It is often adulterated with sodic chloride and sulphate. It gives a fine yellow light when burnt, but if $Na\,Cl$ is present the colour is a yellowish-green. It is usual to mix it with sodic chloride, ashes, &c., to the extent of four times its weight before applying it to the soil. It forms one of the best top dressings for all kinds of corn and grasses. In many cases it is more effective than ammonic nitrate as a manure.

The salts of ammonia form valuable manures. Ammonia $N\,H_3$ is worth about £80 per ton. It is formed on the distillation of coal, and is absorbed in water together with tarry matter $S\,H_2$ and $C\,O_2$. This liquid is put in tanks in which it is heated by steam pipes that drive off the $N\,H_3$ into vessels in which there is $H\,Cl$ or $H_2\,SO_4$, so that ammonic chloride or sulphate is formed, and on the evaporation either of these salts crystallize out.

The ammonic chloride contains about 30 per cent. of $N\,H_3$, while the sulphate contains about 25. There is sometimes present in the sulphate a sulpho-cyanide of ammonia that is injurious to plants. The gas liquor containing ammonia may be very beneficially applied to compost heaps, and when diluted with about four times its volume of water, it may be employed as a liquid manure.

The ammonic salts produce the greatest

effects when applied to the soil on which grasses or cereals are grown, but they are not of much service when applied to leguminous plants. This order of plants, however, by the agency of their large leaves, abstract combined nitrogen from the air, and increase the amount of NH_3 in the soil, hence wheat generally succeeds a clover crop.

Peruvian guano is of a greyish or light brown colour, and has been formed by the excrements of sea-fowl through a long space of time on the shores, rocks, and islets of Peru. As the temperature is high, these excreta are soon dried, and there being no rain the alkaline salts are not carried away, and fermentation is not induced. In other countries, where there is rain, the alkaline salts are carried off, and the moisture and heat induce fermentation, producing NH_3, which, being volatile, escapes. It is composed of ammonic salts and nitrogenous organic matter to the extent of 56 per cent., yielding about 16 of ammonia, but this sometimes falls as low as 12, and sometimes even 9. There is about 22 per cent. of tricalcic phosphate of lime, about 12 of moisture, 9 of alkaline salts, and about ½ per cent. of mineral salts.

About three-fourths of the value of this manure depends on the nitrogen present. Thousands of tons are annually imported, and it is sold at about £14 per ton. It is often adulterated with phosphatic guanos, clay, ochre,

and plaster of Paris to the extent of one-third or a half. When adulterated it weighs much heavier, and when burnt the residue should only form about one-third of the weight of the quantity taken. This manure is chiefly valuable for its contained NH_3, and can be beneficially applied to all kinds of crops. It is applied for roots at the rate of 3 or 4 cwt. per acre, but a better effect is produced by mixing it with twice the amount of superphosphate, and applying about 4 or 5 cwt. of the mixture. A top dress-sing in the spring of 1 or 2 cwt. per acre for corn or grass produces a decided effect.

Guano gives the best results when applied to heavy clay soils containing little organic matter, and for clay loams it is advisable to mix it with phosphates, which are best adapted for light soils.

The phosphatic guanos have been produced by the exposure of the excreta of birds to the action of rain, which has carried away the soluble constituents and left the phosphates and other insoluble matters behind to form a hard rocky material, which requires to be converted into the superphosphate by sulphuric acid before application. These guanos are found in the Caribbean and Gulf of California islands.

All sorts of animal refuse, such as hair, dried blood, feathers, leather, shoddy, horn shavings, woollen rags, &c., are nitrogenous manures. Dried blood is the most valuable, as the others

decompose very slowly. Their decomposition is hastened by putting them in a manure heap that is in a state of active fermentation. Woollen rags and shoddy by treatment with $H_2 SO_4$ are rendered available. Soot, consisting of carbon, various organic bodies, ammonic salts, gypsum and other mineral constituents, is largely used as a manure. The amount of NH_3 varies from 1 to 6 per cent. Its value is chiefly due to the ammonic sulphate present, and it is applied principally as a top dressing to grazing ground in the spring.

Rape-cake used to be employed as a manure, but is now chiefly used as a food for cattle. For wheat it is applied as a spring top dressing, or it is drilled in with the seed. It readily decomposes in the soil, and it produces no effect after one year. It contains about 6 per cent. of nitrogen, about 2½ of phosphoric acid, and about 2 of alkaline salts.

CHAPTER XIV.

THE FORMATION OF VEGETABLE COMPOUNDS.

It is well known to agriculturists that it is a bad plan to grow the same crop too frequently on the same plot of land. For instance, clover will not succeed if sown oftener than once in seven or eight years on the same piece of land. If sown every three or four years the land generally becomes "clover-sick," that is, the soil does not contain a sufficiency of the mineral food required by the clover plant. Again, when turnips are grown too frequently on the same soil, the bulbs become diseased from a deficiency in the supply of the food required by them.

Wheat does not succeed so well if repeated too often on the same land, as it extracts from the soil a certain class of mineral ingredients requiring more of some constituents than of others, so that those constituents of which it requires a large supply become deficient in the soil, until they are supplied naturally or artificially. Wheat takes from the soil four times as

much silica as potash; and beans, another crop that is often alternated with it takes nine times as much potash as silica. When the land does not yield a good crop of wheat from the exhaustion of silica, &c., it will produce excellent beans that do not require so much silica, &c., and when this crop can no longer be grown from the exhaustion of the potash, &c., of the soil a fine crop of corn may be produced that requires less of some constituents and more of others. During the time that the land is under beans the silica available as plant food increases by natural agencies at a greater rate than it is required by this crop, so that when wheat is sown again there will be a sufficiency of this plant food for it. During the period that the land is under beans there is a great demand for potash, and this plant food decreases in the soil, and when put under wheat afterwards the quantity of potash increases by natural agencies in a greater ratio than it is withdrawn by this corn. Flax is another crop which it is not prudential to repeat oftener than once every ten or twelve years. It is only of late that the connection between the soil and the plant has been understood. For some time it was firmly believed that each class of plants excreted from their roots matters that were prejudicial to that class of plant, but beneficial to the growth of other vegetables. Thus it was explained that the

excretions from the roots of a wheat crop were injurious to the growth of another crop of wheat, but favourable to the growth of beans. And in all probability some opinions now considered unassailable will afterwards be found quite erroneous. If we take any particular plant and burn it, we find that it disappears with the exception of a little ash that is left behind. The portion that disappears consists of water and organic substances, and the ash is formed of mineral matter. In the case of the potato about 77 per cent. of water disappears, about 22 of organic matter, and a little more than 1 of ash is left. In turnips 93 per cent. of water, and 6 of organic matter, disappear on combustion, leaving 1 per cent. of ash. In oats, barley, pease, beans, and lentils there is about 3 per cent. of ash, while in wheat and Indian corn there is only about half that amount, rye having 1, and rice seven-tenths of inorganic matter. Thus it will be seen that some plants leave only about half per cent. of ash after combustion, while others leave about six times that amount. Of course the ash or mineral matter is obtained from the soil alone, while the organic matter is principally derived from the atmosphere. There is in the air an inexhaustible supply of matter for the formation of the organic portion of all plants, so that when they refuse to grow, other conditions being favourable, it shows

that there is a lack of mineral constituents in the soil available as food. It is from the atmosphere principally that plants receive many of their most valuable products, such as the alkaloids, albumen, starch, sugar, oil, resin, camphor, &c.

In the numerous species of plants continual chemical changes are always in progress. New substances are continually being formed by a rearrangement of the elements making other compounds. And each species of plant has the power of forming compounds peculiar to itself, which compounds are formed from carbonic anhydride CO_2, water OH_2, and ammonia NH_3, principally by a rearrangement of their elements, together with an elimination of one or more of the elements, such as oxygen. But in many plants chemical compounds are formed from carbon and hydrogen alone, as in the case of the Rosaceæ containing volatile oil in their flowers and petals, the Aurantiaceæ in the rinds of the fruit, the Myrtaceæ and Labiatæ in the leaves, the Umbelliferæ in the seeds, &c.

Oil of turpentine exudes from the various species of pine when cut, and it has been formed from CO_2 and OH_2 by an entire elimination of the oxygen, thus, $C_{10}H_{16} = 10\,CO_2 + 8\,H_2O - O_{28}$. Various volatile oils having the formula $C_{10}H_{16}$ and isomeric with oil of turpentine are found in hops, oranges, lemons, pepper, parsley, savine,

cloves, carraway, camomile, birch, bergamot, elemi, thyme, &c.

Cumol $C_9 H_{12}$ formed from 9 of $CO_2 + 6 H_2O - O_{24}$; Cymol $C_{10} H_{14}$, formed from 10 of $CO_2 + 7 H_2O - O_{27}$; the oil of cedar $C_{16} H_{26}$ formed from 16 $CO_2 + 13 H_2O - O_{45}$; oil of peppermint $C_{10}H_{18}$ formed from 10 $CO_2 +$ 9 $H_2O - O_{29}$; and attar of roses perhaps $C_{10}H_{20}$, from 10 CO_2 + 10 $H_2O - O_{30}$. Many of these oils on oxidation form resins and camphors, thus, $C_{10}H_{16} + O = C_{10} H_{16} O$ ordinary camphor, which is formed in many plants by the oxidation of their essential oils.

Camphor is contained in solution in the oils of spearmint, pennyroyal, marjoram, and rosemary.

The resins exude from various species of trees when cut. In most cases they are formed by the oxidization of essential oils in the plants themselves, or resin $C_{20} H_{28} O$ may be formed from 20 $CO_2 + 14 H_2O - O_{53}$.

Oil of cinnamon $C_9 H_8 O$ is formed from 9 $CO_2 + 4 H_2O - O_{21}$, and cinnamic acid $C_8 H_7 COHO$, from 9 $CO_2 + 4 H_2O - O_{20}$.

Oil of bitter almonds, $C_6 H_5 COH$, is formed from 7 $CO_2 + 3 H_2O - O_{16}$, and benzoic acid, $C_6 H_5 CO Ho$, from 7 $CO_2 + 3 H_2O - O_{15}$.

Acetic acid, CH_3COHo, is formed from 2 $CO_2 + 2 H_2O - O_4$; butyric acid, C_3H_7COHo, from 4 $CO_2 + 4 H_2O - O_{10}$; valeric acid, C_4H_9COHo, from 5 $CO_2 + 5 H_2O - O_{13}$;

stearic acid, C_{17}, H_{35} $COHo$, from 18 CO_2 + 18 $H_2O - O_{52}$.

Elaterin, C_{20} H_{28} O_5, is formed from 20 CO_2 + 14 $H_2O - O_{49}$; hæmatoxylin, $C_{16}H_{14}O_6$, from 16 CO_2 + 7 $H_2O - O_{33}$; salicin, C_{13} H_{18} O_7, from 13 CO_2 + 9 $H_2O - O_{28}$; pectin, C_{32} H_{40} O_{28}, from 32 CO_2 + 20 $H_2O - O_{56}$; and mannite, $C_6H_{14}O_6$, from 6 CO_2 + 7 $H_2O - O_{13}$.

Starch, cellulose, gums, dextrine, glycogene, and inuline, C_6 H_{10} O_5, are formed from 6 CO_2 + 5 $H_2O - O_{12}$; grape sugar, fruit sugar, sorbin, eucalin, and galactose, C_6 H_{12} O_6 are formed by the assimilation of water by starch, &c., or from 6 CO_2 + 6 $H_2O - O_{12}$; and cane sugar, milk sugar, melezitose, and mycose, C_{12} H_{22} O_{11}, from 12 CO_2 + 11 $H_2O - O_{24}$.

Ammonia is supplied to the soil from the air by the agency of rain and the decomposition of organic matter.

Caffeine, C_8 $H_{10}O_2$ N_4, is formed from 8 CO_2 + 4 $NH_3 - OH_2 - O_{13}$; amygdalin, $C_{20}H_{27}O_{11}N$, from 20 CO_2 + 12 H_2O + $NH_3 - O_{41}$; nicotine, $C_{10}H_{14}N_2$, from 10 CO_2 + 2 NH_3 + 4 $H_2O - O_{24}$; asparagine, C_8 H_{10} O_8 N_2, from 8 CO_2 + 2 H_2O + 2 $NH_3 - O_{10}$; and morphine, C_{17} H_{19} O_3 N, from 17 CO_2 + NH_3 + 8 $H_2O - O_{39}$.

Above we have seen that no organized vegetable product is formed of any element alone, for in that case there could not be any chemical action, but carbon and hydrogen are formed into volatile oils in plants by the vitality existing in

them. When only one atom of oxygen is combined with carbon and hydrogen we have the resins and camphors that are formed in so many plants. When there are two atoms of oxygen present with carbon and hydrogen, we have produced the fatty acids which are found in both vegetables and animals and organic acids, in which there are three, four, six, seven, eight, nine, ten, or twelve atoms of oxygen combined with carbon and hydrogen. When the quantity of oxygen is just sufficient to form water with the hydrogen, we have sugar, starch, cellulose, woody fibre, gum, &c., produced.

Nitrogen is associated with carbon, hydrogen, and oxygen, as in the alkaloids, caffeine, strychnine, nicotine, quinine, &c., and in the proteine bodies albumen, fibrine, and caseine. Sulphur is contained in the albuminates, and sometimes phosphorus as well. Sulphur also exists in combination with carbon, hydrogen, and nitrogen, as in the oil of mustard. Plants contain in addition to the above, potash, lime, magnesia, and soda with phosphoric, sulphuric, hydrochloric and carbonic acids. Iron, silica, manganese, with traces of fluorine are present with iodine and bromine in marine plants. Water is always present, sometimes from 85 to 96 per cent., together with alumina and baryta, and occasionally with nitrates.

Plants obtain their carbon either from the CO_2 in the air or from that in solution in water

around their roots. Those growing on naked rocks obtain their carbon entirely from the CO_2 of the air. When they are dried, the carbon forms about two-thirds of their weight.

Plants obtain their hydrogen from the decomposition of water and ammonia by vital and chemical agencies.

Plants receive their supply of oxygen from the decomposition of CO_2 and OH_2, but in all cases more or less of this oxygen is liberated to the air. In some of the compounds formed in plants the whole of the oxygen is liberated, as in the case of the essential oils.

Plants derive their supply of nitrogen from ammonia, NH_3, or nitric acid in combination. They cannot assimilate nitrogen, and when it happens to be absorbed into the plant it is always liberated unchanged, owing to the indifference of nitrogen for the other elements, but ammonia is very readily decomposed and immediately enters into combination with other compounds in the plant, forming compound ammonias, amides, imides, amidoacids, albuminates, &c. Plants cannot exist in soils that do not contain ammonia or substances readily convertible into ammonia, which may be derived from the air or the soil. It is formed by putrefactive processes, thunderstorms, volcanic eruptions, &c. It is also found in rain water and snow, and thus finds its way into the soil.

Plants must procure the sulphur they require

from the soil, as it does not occur in the air, and the principal form in which it is found therein is the sulphate, from which they have the power of decomposing and assimilating this element.

The roots of plants have the power of selecting certain constituents and rejecting others.

The cells of plants also have the power of building up compounds from their constituents, and also the power of breaking them up. Compounds are formed from $C\,O_2$ and $O\,H_2$ in the cells with the albuminous matter present, and potash, soda, phosphorus, and various salts, and the presence of light. Oxalic acid may be formed first, as it is one of the simplest compounds. The cell separates one equivalent of oxygen from 2 $C\,O_2$, leaving $C_2\,O_3$ anhydrous oxalic acid, to which $O\,H_2$ is united, forming $(CO\,Ho)_2$ oxalic acid, which, by taking up water and losing oxygen, yields malic acid, thus :—

$$2\left\{\begin{array}{l} CO\ Ho \\ CO\ Ho \end{array}\right\} = C_4\,O_4\,H_4\,O_4 = C_4\,H_4\,O_8 + O\,H_2 =$$

$$C_4\,H_6\,O_9 - O_4 = C_4\,H_6\,O_5 = C\ Me\ Ho\ (Co\ Ho)_2$$

malic acid. Tartaric acid is produced in the same way, only losing 3 of oxygen instead of 4.

Citric acid $\left\{\begin{array}{l} C\,H\,Ho \\ C\,H_2 \\ C\,H \end{array}\right\}(CO\,Ho)_3$, is produced from three equivalents of oxalic acid, taking one of $O\,H_2$, and losing six of oxygen.

The roots of plants take up fluid matters, which pass upwards through the porous vessels and intercellular spaces of the stem, chiefly through the alburnum, and onwards along the upper and lower surfaces of the leaves, and downwards through the laticiferous vessels of the inner bark, the cellular tissue of the bark and inwards along the cells of the medullary rays. By the agency of light and air, oxygen is exhaled from the leaves to a greater or less extent, and the hydrogen and carbon become fixed, forming substances consisting of these elements and other compounds with the oxygen that has not been exhaled.

Water is also given off from the leaves. Other changes take place in the tissues of the bark, and the carbonic anhydride and water in the sap becomes decomposed, and combinations with nitrogen, &c., are produced, forming secretions in the cells and intercellular passages which vary with the species of plant. The sap, in its detour from the roots and back again, nourishes the various organs of the plant in its passage, and is subject to continual change by the agency of the vital force forming woody fibre and the various compounds found in vegetables.

When the vital force ceases, decomposition sets in, and the plant becomes finally converted into water, carbonic anhydride, ammonia and

ashes, just as in burning it, but the decay takes years, and the combustion only a few minutes. On decaying, the plant becomes changed into a brown substance, termed humus, that forms a valuable manure. On burning wood, oxygen unites with the carbon of the wood, forming CO_2, and with its hydrogen forming OH_2, and its nitrogen and hydrogen form NH_3. An oil consisting of carbon, hydrogen, and oxygen, on burning, forms merely water and carbonic anhydride.

CHAPTER XV.

THE ROTATION OF CROPS.

IT is stated above that soils are exhausted by the assimilation of the mineral constituents of the soil, and not at all by the formation of organic compounds, of which I have just spoken somewhat minutely. The amount of mineral matter soluble in water is very small, being only, on the average, about .2 per cent. of the soil, and the quantity required by plants is also very small, varying from about .5 to .3 per cent. of the plant. So that the supply of the remainder of the plant, 97 to 99½ per cent., is derived in a great measure from the atmosphere, which is capable of supplying the whole amount of water and organic matter. The rain, dew, &c. supplied by the atmosphere furnishes, not only water but ammonia, that is required for the formation of proteine compounds in the plant. And the carbonic anhydride in the atmosphere is capable of supplying all the carbon required in the formation of organic compounds. It is not,

therefore, essential to apply to the soil organic manures, or even those containing nitrogen, for the atmosphere contains an inexhaustible supply of organic materials. However, the application of manure containing organic matter is useful, since its solubility in the water of the soil increases the amount of soluble mineral matter, and at the same time enables the plant to extract more organic material from the air. This soluble carbonic anhydride and ammonia in the water is taken up by the roots of plants and assimilated.

The mineral matter contained in the manure is really essential, for if it is not supplied when land has become exhausted, plant growth receives a check from the want of this food. Plants refuse to grow, and certainly do not come to perfection, when any of the mineral constituents required by them exist in the insoluble form in the soil; just in the same way as animals cannot contrive to live when some essential constituents are not supplied to them in their food. The quantities of the several mineral constituents of soils required by different plants vary thus:—oats, beans, and turnips take from the soil two, three, and five times as much potash as wheat; barley extracts large quantities of silica from the soil, and oats require five times as much lime as wheat. So that if there was not sufficient potash in the soil for the production of

turnips there might be enough for this corn. When the lime in the soil was insufficient for the growth of oats there might be enough for wheat. Hence the utility of a rotation of crops. Some plants are well adapted to succeed others. Thus wheat follows clover, beans, or pease, since these plants leave roots and leaves in the soil that furnish a supply of nitrogen to that crop. Plants differ in their modes of obtaining food—some have a large amount of foliage like green crops, and take nearly all the carbonic anhydride, ammonia, and water that they require from the atmosphere, while other plants, like the cereals, have little foliage, and are more dependent on their roots for their supply of these aqueous and gaseous compounds. It is, therefore, advantageous to alternate crops taking their organic constituents principally through their roots with plants taking them chiefly by means of their leaves. Again, it is well to alternate plants taking their supply of mineral foods from different parts of the soil: for instance, wheat and barley usually alternate well, since the roots of the latter are confined to the surface soil, while those of the former penetrate deeper, extracting their food from a different part. The available mineral constituents of the surface soil may be exhausted while that of the deeper soil is intact, and *vice versâ*. Red clover, parsnips, carrots, &c., penetrate deeply into the soil in

search of food. This is the reason why clover succeeds in the South-east of England, withstanding droughts when other plants succumb.

Land, no matter how fertile it may be, becomes exhausted eventually by the repeated growth of plants, for there is a continual withdrawal of mineral constituents from the soil without any return. And even supposing the whole of the crops produced on any farm is passed through the bodies of animals, and the resultant manure is applied to the land, fertility cannot be maintained, since stall-fed animals assimilate about 17 per cent. of the food given to them, while beasts of burden not only assimilate about the same amount, but an additional 25 is lost, so that the former return to the soil about 83 of the food they consume, while the latter only return about 58. So that in no case can all the mineral constituents, taken from any piece of land, be returned to that land by the application of the farmyard manure, produced from the consumption of the crops grown on it alone. Any plot of land must therefore eventually become exhausted unless more farmyard manure is applied to it than is produced from it, or unless there is an application of artificial manure or a supply of mineral constituents from some other source. If there is no such application of farmyard or artificial manure, the land must be allowed to lie fallow

until fresh mineral constituents available as plant food have been formed by natural agencies. This course was and is now adopted in a more or less nomadic state of society.

In this country farmers cannot afford to fallow their land, but by turning over and pulverising the soil they can produce as great an effect in a single season as would require some years to accomplish if the land were left to nature alone. A soil requiring frequent fallowing should be converted into pasture land permanently. Occasionally, upon clay soils, foul or wet pieces of land are fallowed, but the remainder of the fallow will be sown with suitable forage crops. Instead of the bare fallow, root-crops are grown on a large class of soils. The object of fallowing is to enrich and clean the land from weeds, and this twofold purpose is effected by green fallowing, as root-crops do not thrive without a plentiful supply of manure that enriches the soil for the following crop, and the space between the roots permits a thorough cleansing from weeds. As these green crops are sown during the months of May, June, or July, ample time is allowed for the cultivation of the land after the removal of the previous crop during August or September. The application of the manure produced, by their consumption on the farm, counteracts the exhaustion that would be produced if they were sold. Corn is an exhausting crop when sold, but

when used for feeding stock it supplies to the soil at least about 60 per cent. of the plant food extracted from it originally. Corn renders land foul, as there is not the same facility for removing weeds as in the case of roots. The simplest rotation is the alternation of two crops on a piece of land, as that of (1) beans and (2) wheat, on clay soils rich in plant food. A three years' rotation of (1) green crops, (2) grain crops, and (3) grass, is occasionally followed. The green crops, turnips, mangold wurzel, &c., are manured, the grain crop is laid down with grass and clover, and the grass is used for making hay and house-feeding cattle. By this rotation the same crop is grown too frequently on the same soil, and the labour is much increased by the preparation of grass land for roots. A four years' rotation, very extensively practised, has been termed the Norfolk, from its general adoption in that county. It is a course that is very suitable for free or light soils, and consists of (1) green crops manured, often eaten on the land by sheep ; (2) grain crop (barley) with grass and clover seed. (3) Grass, (4) grain (wheat). By this system one half the land supplies fodder, and the other half grain, which is grown after the land has been manured, so that good crops are produced. If there is any sign that a crop suffers by being grown every fourth year on the same land, then the portion of the

land on which this particular crop is produced may be divided into two and another plant of an allied species sown on the other half. For instance, if turnips become diseased when grown every fourth year on the same soil, the portion allotted for this crop should be halved and mangold sown on one part and turnips on the other. Then after four years plant turnips where the mangolds were before, and *vice versâ*. In this way any portion of the soil would only produce turnips every eight years. In the same way, clover may be alternated with rye-grass, and clover sickness prevented. However, by good tillage and the application of manure, the Norfolk course may be carried out in its entirety. On poor land the production of a grain crop every second year is exhausting, especially if the roots of the grain always derive their nourishment from the same part of the soil. As barley is alternated with wheat in the eastern counties of England, the exhaustion is not nearly so great as if wheat was produced every second year. In other parts of the country and in Ireland, where oats are sown instead of barley, the soil becomes sooner exhausted, and more manure is required to keep up the fertility. The four-course rotation is converted into a five-course by allowing the grass of the third year to remain unbroken the next year. This rotation has been termed the Northumberland, because it is extensively followed in that county, Durham,

Cumberland, and in other parts of England, where the climate is moister than in the south-east of Great Britain. This rotation is followed to a considerable extent in Ireland. The Northumberland course consists of (1), roots manured, (2), barley or wheat with grass seeds, (3), grass, (4), grass, (5), oats. In this rotation the wheat follows roots instead of lea, as it does in the Norfolk rotation, and it is not so successful in the North after grass as in the South of England; besides, grass land intended for oats can remain unbroken up to the end of the year, but for wheat it should be broken up early in the autumn, by which the herbage is lost for feeding the cattle. The first year's grass is usually mown, and that of the second year pastured. The second year's crop is never so heavy as the first, however; it varies according to the humidity of the climate, and other causes. There is also a saving of labour by having two-fifths of the land under grass, which is still further diminished by keeping it unbroken for another year when half the farm is under pasture. In this way a six-course rotation is formed by having grass instead of oats in the fifth, and this grain in the sixth year. In this rotation oats are grown in the sixth year as before, and generally in the second year, instead of wheat. One-sixth of the farm is in roots, and one-third in grain. This rotation is more suitable for lighter land and for hilly farms than the five

courses, as only manure for one-sixth of the land has to be carted. The climate in hilly districts is moister, and therefore well adapted for pasturage. The grass roots, when the lea is broken up, by their decomposition furnish food for the oat crop.

There is another six-course rotation in the East Lothians in Scotland, where a rich, loamy soil has been formed from the Devonian or old red sandstone formation, which is favourable to the growth of potatoes. It consists of (1) green crops (manured); (2) barley or wheat (half manured); (3) grass with clover; (4) oats (top dressed); (5) potatoes or beans (manured); (6) wheat. With the exception of the fifth and sixth years, this rotation is essentially the same as the Norfolk four course. By this system, one-sixth of the land is manured for roots, and one-sixth for potatoes or beans, so that at least one-third of the farm is fertilized yearly. One-half the land is under grain in the second, fourth, and sixth years of the rotation, and each corn crop just comes in the place best suited for it. And as different classes of corn crops are produced in different parts of the rotation no plant is produced on the same soil oftener than once in six years, so that disease or sickness is uncommon with this system.

Other courses of rotation are followed in other parts of the country besides those given

above. In the very rich clays of the Carse of Gowrie the rotation consists of (1) fallow, (2) barley, (3) clover, (4) oats, (5) beans, (6) wheat. The beans are manured and are followed by wheat, which also follows the fallow, and the oats follow clover, so that with barley two-thirds of the farm is under grain. On the rich soil of Holderness one-half is under wheat, the rotation being (1) fallow, (2) wheat, (3) beans, (4) wheat, (5) clover, (6) wheat. On clay soils not so rich we may have (1) fallow, (2) wheat, (3) beans, (4) oats; or (1) fallow, (2) wheat, (3) clover, beans, or oats. In these cases the fallow may be bare or cropped. In Bucks and Oxon a common rotation is (1) fallow, (2) wheat, (3) beans, (4) pease or clover.

As a general rule with regard to rotations on heavy clay lands or strong and stiff soils, wheat, beans, mangold wurzel, cabbages, kohl rabi, &c. succeed best. Light soils are suited for turnips and barley, and calcareous soils for clover, pease, vetches, and peaty soils for oats, potatoes, rape, and kohl rabi; but as the soil and climate vary in different districts, it is evident that no system of rotation should be carried out without variation, and the fluctuations in the market value of certain produce furnish an additional reason for a change in any system. If the price of corn crops increase, the farmer can occasionally, when his land is in good condition, take oats or barley after wheat on heavy

or light land respectively. He can sometimes under favourable circumstances take repeated crops of corn without detriment to his land. By the rotation of crops the continued cultivation of medium lands is rendered possible, but on naturally rich lands the same crop can be produced repeatedly for a certain length of time before a rotation is introduced. By a rotation the risk of the farmer is lessened, for if one crop does not succeed, another probably will; whereas if all his land was under one crop and that failed, he might be ruined monetarily. With a rotation farm labour is more equalized during the year, weeds can be removed, and there is a constant supply of food.

CHAPTER XVI.

SEEDS — VITAL POWER — GERMINATION — CHANGE OF SEEDS AND DISEASES OF CROPS.

THE seed of a plant corresponds to the impregnated ovum of an animal, for from the latter the young animal is produced, and from the former the vegetable is yielded. The seed is generally contained in some form of vessel or covering, the whole being called the fruit. The ovule usually contained in an ovary is fertilized by the pollen discharged on the stigma penetrating down the style to reach it, and forms the embryo or embryo plant, which the seed contains, together with a store of nutritive matter enclosed by protective appendages. When the skin of the seed is removed we find that the embryo occupies either the whole or only part of the interior. In the pea and bean, for instance, the whole is embryo, while in the seed of cereals only a small portion forms the embryo plant, while the remainder consists of a store of nourishing matter called albumen, which, after the plant is sown, becomes soluble, and is

utilized as food by the young vegetable until it can take nourishment from the soil. The embryo consists of the young root, the young stem, and the cotyledons or seed leaves. There are two kinds of embryos in flowering plants—those containing one cotyledon, and those containing two. After removing the skin from various seeds, *e.g.* the pea, these parts of the embryo plant may be seen.

In the pea and many other seeds the nutritive matter is so incorporated with the embryo plant that, together, they form the whole of the interior of the seed, while in other cases the nutritive matter is separated from the embryo, as may be seen in a seed of wheat, oats, or barley. In the seeds of some plants, as in the orchids, the embryo is not sufficiently developed for us to see the parts.

In order that a seed may develop into a plant it is necessary that a combination of circumstances should arouse the seed from its state of torpidity or suspended vitality. The essentials for growth or germination are the presence of a certain temperature, a certain degree of moisture and a supply of air. Naturally seeds when ripe fall to the ground, and often are carried by various agencies to a greater or less distance from the plant producing them. When the seed is placed so as just to be covered by earth from the light, the necessary heat, air, and moisture being present it sprouts, the radicle descending to form

the root, and the plumule ascending to form the stem with its appendages. Seeds when sown naturally have only a slight covering of soil, and in the sowing of seed we should imitate nature, and not bury it so deep that the proper access of air is prevented, thus delaying the germination of the young plant wholly or partially. Seeds should be placed at even and moderate depths, not more than two inches. The plants spring up irregularly when sown at different depths. The soil should be drained so as to carry away any excess of moisture that would chill the soil and prevent the free access of air to the seed. The drainage also allows fresh supplies of nourishing fluid to carry food and warmth to the roots. To produce really good plants the soil must be prepared so that they can obtain a regular and sufficient supply of the food required by them. In undrained land the water is stationary, and there is but a small supply of fresh food. The soil should be well pulverized and neither too dry nor too moist, for when dry the cavities in the interior of the particles of soil are filled with air, and when the soil is wet or undrained these cavities are filled with moisture. But in a drained soil the particles are moist and their cavities enclose air, hence the soil contains the necessary moisture and air, and when the temperature is within certain limits the plant is furnished with every essential of growth.

By various experiments it has been found that seeds germinate best when in the dark. With regard to light it has been found that the blue rays cause rapid growth, and the red rays are favourable to it, while the yellow rays have been found to retard vegetation.

With regard to temperature some seeds will bear a heat that will destroy the vitality of others. Seeds have been known to germinate after exposure to a cold of -39 deg. C., and a heat of upwards of 39 deg. C., but it would appear that for the successful growth in general, a temperature of not less than 15 deg. C., nor above 27 deg. C., is requisite. Some plants are adapted to grow in hot, some in cold, and others in temperate countries. Most plants have certain limits of temperature beyond which they will not come to perfection. Thus wheat cannot be successfully grown in countries where the limits are above 25 deg. C., or below 8 deg. C., and in the latter case it takes twice the time to ripen. Confervæ will grow in boiling springs, and chara vegetates in the hot springs of Iceland. The vitality of seeds is not destroyed by a heat of 35 deg. C. in water or 45 deg. C. in earth. It is stated that plants have been seen growing in a hot spring in the Indian Archipelago exposed to a temperature of 85 deg. C. The microscopic plant, the *palmella nivalis*, grows in the snow, and lichens are only found where the cold is intense.

As stated above, the presence of air is necessary for the germination of the seed, and to secure the necessary air the depth to which the seed is placed in the soil should not exceed 2 inches. For it is found that the depth of 1 inch gives the best result, all the seed germinating and appearing above ground in the shortest time; however, when the depth is less than 1 inch the plant may get to the surface somewhat sooner, but more than one-tenth of the seed will not germinate. If the time required to come to the surface at a depth of 1 inch is taken as unity, then the times at 2, 3, 4, 5, and 6 inches will be as the numbers 1.5, 1.6, 1.7, 1.8, and 1.9, and the percentage of seeds sprouting at these depths will be as the numbers 90, 80, 50, 40 and 15. At a depth of 7 inches and above the seeds will not germinate at all, but the vitality or ability to sprout is merely suspended, and if by any accident it is brought nearer the surface it will probably germinate; however, the power to do so varies with the kind of seed. In the drainage or trenching or cutting the soil for railways, seeds that have been buried for unknown periods have vegetated, producing plants uncommon or unknown in the locality. When a forest happens to be burnt previously unknown plants make their appearance, and after the Fire of London in 1666 uncommon plants were observed growing on the waste lands. And the vegetation of

seeds that were found in the tombs of the Incas demonstrate the great length of time that they can maintain their vitality. When exposed to the air seeds usually lose their vitality in a few years, but this varies with the kind, *e.g.* those containing fixed oils do not keep well.

Dry seeds will not sprout because the plant must take its food in solution, and until water is absorbed by the seed no circulation can take place. The seed, by absorbing moisture, becomes swollen and softened, the matter stored up in the cotyledons of ex-albuminous and the albumen of the albuminous seeds become converted into the soluble form, starch being converted into sugar by a nitrogenous ferment termed diastase. During this conversion carbonic anhydride is given off, oxygen being absorbed and heat produced by the chemical action. This change of the starch of seed into sugar is demonstrated in the malting of barley. The embryo plant derives its nourishment at first entirely from the cotyledons or the perisperm, the root beginning to grow downwards and the plumule upwards at the expense of the nutriment stored up in the seed.

By cultivation many changes are effected in the various parts of the plant, as may be observed in the cultivated potato, the turnip, carrot, cabbage, cereal crops, &c. The quantity of starchy matter and cellular tissue is very

much increased. Plants have certain valuable characters stamped upon them by the skill of the cultivator, which characters he strives to improve and perpetuate by high cultivation and arduous attention. But these properties are liable to deteriorate in the course of time, hence the skilled cultivators will import the best seeds from the best-cultivated districts to sow upon his farm. The colour of the seed should be uniform, its constitution sound, and of moderate or large size. The effect of good imported seed on badly-farmed land is most apparent, but on all farms it pays to change the seed occasionally.

As animals are affected by various diseases, which are the result of a neglect of the ordinary laws of health, so are plants.

The health of plants requires an assiduous attention that is often not bestowed upon them. They require certain conditions of the constituents of soil, air, light, heat, and moisture, and if any one or more of these is in excess or defect disease will follow. There are also diseases due to parasitic plants and the attack of insects. In the absence of sufficient food in the soil the plant is weakly and does not attain perfection; and when the food is in excess there is an over-development of tissue causing a predisposition to disease. The state of the air as regards electrical condition, the prevalence of cold, hot, or wet weather, or an excess or

deficiency of moisture, and miasmatic or injurious gases produce beneficial or injurious effects on vegetation. The various plant epidemic diseases would appear to be due to some fatal influences conveyed by the air. The deficiency of light causes the diseased state of tissue called blanching, and an excess of it to plants addicted to shady or dark places may produce disease. Frost has an injurious action on the flowers, leaves, and other parts of plants, and an excess of heat is capable of causing disease or barrenness. An excess of moisture may cause a dropsical state of the plant, and a deficiency is most prejudicial to its welfare.

Bunt is a disease peculiar to wheat, caused by a parasitic fungus. It can be prevented by the dressing of the seed before sowing, or by the selection of that which is clean. The seed may be dressed with quicklime, salt, chloride of lime, sodic sulphate, a weak solution of cupric sulphate, &c. Even washing with water removes a large number of the spores from the seed. Bunt is usually caused by the mixture of sound with unsound seed, by scattering the bunt dust about, by thrashing, or by manuring with the straw of the infected grain.

Blight is a very comprehensive name among farmers, being frequently applied to almost every disease of the plant, due to soil, air, insects, or fungi, but it is often limited to the disease caused by the fungus *Uredo caries*

filling the interior of the grain with a powder of a very disagreeable odour.

Mildew is applied to the disease of plants known by blight, bunt, brand, rust, &c., and is also applied to the white, mealy patches appearing on the leaves of plants. Mildew often appears on the leaves of plants towards the end of summer, when vegetable life is waning. This disease may be caused by the spores of the fungi brought to the plant by the air or the soil, or by unfavourable weather.

Rust is a name applied to a disease of cereal and other grasses. It appears in the form of orange yellow or brown spots on the ears of the grasses, the leaves, and stems. It is caused by the fungus Uredo, and there is no remedy for it. Heavy manuring tends to produce this disease.

The Uredo, a genus of parasitic plants, consists of many genera, containing a vast number of species that infect all flowering plants from the arctic to the equatorial regions. Every kind of plant has its own peculiar species, that attack every part of it except the roots. It is believed that the spores are taken up by the roots of plants from the soil. Luxuriant vegetation is most liable to their attacks, which sometimes affect the inner tissues of the plant.

Anbury is a name given to a disease that affects turnips, caused no doubt by the too fre-

quent repetition of this crop upon the same land. The degree of repetition will depend upon the nature of the soil and the manuring. The application of lime has been found beneficial in some districts. The root instead of swelling into one portion becomes divided into several, hence this disease is commonly known as "Fingers and Toes." The root becomes woody and the excrescences rot, and attract and contain plenty of maggots and eggs. The Norfolk turnips are exempt from this disease.

Clubbing is a diseased growth in the upper part of the root of the turnip, cabbage, and other *Brassica*, caused by the larvæ of various insects. This disease may be prevented by a change of crop, or by dressing with wood ashes or quicklime, or by cutting off the excrescences if not too numerous.

The potato disease has been known in Europe since 1842, and in 1846 it came to a crisis in Ireland causing a severe famine. It was, doubtless, due to the continuous cropping of the land with potatoes. Although a great deal of attention has been paid to this disease, and a vast amount of literature has been produced upon the subject, still the nature of this malady is rather obscure. It has been ascribed to various insects and causes, but as the fungus *Botrytis infestans* has always been found present it must have something to do with the complaint. Some observers state that it is due to *acari*, others to insects and even infusoria in

the tissues of the plant. It usually attacks the leaves first and then the tubers, in which it may remain dormant only to break out in the following spring. It causes brown spots on the outside of the leaves, then spreading rapidly, they as well as the stalks decay.

The hop flea does much damage to the young hop shoots in spring. It belongs to the same genus of coleopterous insects as the turnip flea, and is about one-tenth of an inch long.

The hop fly causes the chief difference between one year's crop and another. It is a species of aphis or louse, settling on the stems and under-side of the leaves of the hop plant, doing great damage to the crop, as no very successful means have been adopted to destroy it.

There are numerous insects attacking every species of plant. Coal tar is used to destroy the wire worm, ammoniacal liquor and tobacco vapour for the aphis or louse, sulphur vapour for the red spider, &c.

Canker is a gangrene causing an alteration in the cells, leading to their decay. It begins in the young shoots and branches of fruit trees, proceeding downwards, ultimately killing the tree. Branches that have received a wound, or that have been attacked by frost, are liable to canker; wet soils and grafting also induce this disease. It is sometimes prevented by cutting, in order to cause the tree to throw out new branches.

CHAPTER XVII.

MALT.

THE principal varieties of barley grown in England are the Chevalier, the Norfolk, the early English, and the common. The Chevalier gives the greatest yield, and, as the quality is superior to the other kinds, more of it is grown. Most of the barley produced in England as well as nearly three-quarters of a million tons that are imported, is used for the manufacture of ale, beer, and porter, and the distillation of spirits. The finest qualities are required for the brewing of ale and porter, while the medium does for distillation. The best barley, known by the weight and the silvery colour of the husk, is produced by the English farmer, and finds a ready market and a high price. Barley of first class quality should have a round plump kernel, enveloped by a bright, thin, wrinkled husk. The kernel is white when broken, and sweet when eaten. The purchaser should observe that the grain is of

uniform size and colour, and should be able to judge of its uniform germinating power. He should also prefer the grain containing the least albuminous matter and the greatest amount of starch. Even that containing the smallest quantity of nitrogenous matter has far more diastase than is sufficient to convert the starch into sugar, as one part of the former is sufficient to effect the change in about two thousand parts of the latter. By the way, sugar itself has been very much used lately for the manufacture of beer, thus reducing the quantity of barley that is required. The increase in the consumption of sugar for this purpose is to a great extent due to the inferior quality of the barley caused by the wet weather; and foreign barley in transit is liable to be wetted and its capability of producing good malt considerably diminished. Previous to malting the grain should not be allowed to become damp, since the moisture will set up fermentation and cause the barley to smell disagreeably.

There has been a considerable augmentation in the area under barley, there being an increase of about 60,000 acres in Lincoln, Norfolk, Suffolk, and Essex alone in the year 1879 over 1878. Barley does not bear rain so well as the other cereals. In fine seasons the quality is better, and is more in demand by the maltsters, but when wet it has often to be sold at reduced prices to the distillers.

Barley contains about 68 per cent. of starch, 12 of water, 10 of albuminoids, 5 of sugar, 4 of gum, and 1 of resin. The percentage of albuminoids is often less than the amount given, and when so is preferable for the maltsters.

The conversion of starch into sugar is well shown in the malting of barley, which is converted into malt by four separate processes. It is first put into a stone or wooden cistern and just covered with water, then left for forty hours, during which time the barley swells considerably by the absorption of water. The weight of the barley will be increased from one-tenth to about one-half by the absorption of water. The better the grain, the more water it will take up. The excess of water is drained from the cistern, and the barley is thrown in a heap upon the floor, and allowed to lie for upwards of twenty-four hours, during which time the temperature rises 5 or 6 deg. C., some of the water being given out and a partial germination taking place, the primitive stem and little rootlets being formed; and this growth is further encouraged by spreading the grain over the floor to a depth of about 15 inches, which is gradually reduced by repeatedly turning it over a larger area of the floor until the depth is about 6 inches. The germinating process will take from ten days to three weeks, according to the temperature of the atmosphere. By this

time the rootlets are much increased in length, and the further growth is stopped by spreading the grain on a perforated floor over stoves, the temperature, increasing from 32 to 60 deg. C., dries the grain and the radicles or rootlets break off, and are removed by a wire sieve. The higher the temperature to which the grain is subjected in the kiln the darker the malt, the different shades of colour being used for the various kinds of beer or ale, the darkest being used for porter. By the conversion of barley into malt there is a loss of 8 per cent. in the weight, 100 parts of barley giving 80 parts of malt, allowing the barley to contain 12 per cent. of water; but there is an increase of bulk, 100 measures of the barley increasing sometimes to 109 measures of malt.

In the malting of barley the quantities of starch, sugar, and gum are considerably increased. The starch is almost doubled, the sugar is trebled, and the gum is almost quadrupled. The malt contains about 56 per cent. of starch, 30 per cent. equally divided between sugar and gum, the remaining 14 per cent. being composed of 2 per cent. of gluten and resin, there being 12 per cent. of a starchy cellulose nitrogenous mixture called "hordein," in the absence of a better name. In order to convert this large quantity of starch into sugar, the malt is ground and afterwards put into a

mash tun or churn, in which it is agitated by poles at a temperature of about 72 deg. C. which gradually decreases to about 60 deg. C. as the diastase of the malt acts on the starch, converting it into grape sugar. This converting action is continued, more water being added, until all excepting some insoluble matter and the husk has been changed into the sweet wort or sugar.

Barley has a feeding value of .85 compared with hay or wheat as unity, and dry malt without the sprouts has about the same feeding value, being .87. The fresh malt with the sprouts has only about half the feeding value of hay or wheat grain, and brewers' grains about one-half the value of the sprouted malt.

The radicles or cornings removed by the wire sieve, called malt dust, contain much of the nitrogen of the barley, and have a feeding value one-fifth higher than wheat or rye, grain or hay. Brewers' grains, when given to cattle, increase the flow of milk, but the quality is not so good. However, when they are sold at about 2d. a bushel they form a cheap food for cattle, with which other food having a higher nutritive value should be given. Barley meal forms an excellent food for swine, capable of increasing the weight of the pig by one-fifth the quantity of the meal.

CHAPTER XVIII.

NATURAL AND ARTIFICIAL GRASSES.

THE grasses are found in every part of the world. They are indigenous plants containing about 4,000 species, or about one-twentieth of all the known flowering ones, and by supplying food for man and animals they are one of if not the most important and valuable orders of vegetables. The cereal grains are grasses supplying food for man, and the various true or pasture grasses furnish food for cattle. They grow on all kinds of soils—on the rich moist, on the dry, sandy, and sterile, on the sea coast, in marshes, &c. The grasses are annual or perennial; the roots are fibrous; the stems are cylindrical, hollow, and jointed; the leaves are narrow, long, and alternate; the flowers are hermaphrodite or unisexual, arranged in spikelets, racemes, or panicles; the fruit is caryopsis, that is, the pericarp is incorporated and inseparable from the seed, which consists of an embryo lying at the base, and outside of a large

farinaceous albumen. The seeds of the cereals, containing upwards of 40 and less than 70 per cent. of starch, and more than 7 per cent. and less than double that amount of albuminoids, form the staple food of nearly the whole human race. The grass-rice yields the principal food of the teeming populations in warm countries. Beer and ale are made from the malt of barley, and spirits by distillation. From the sugar-cane or grass the largest supply of sugar is obtained, and from it rum is also prepared. The grasses also supply fodder for cattle; and the various kinds are applied to an almost infinite variety of economical and valuable uses that would be too tedious to mention in detail.

The grasses are divided into the natural and the artificial. There are upward of one hundred species of natural grasses found in the United Kingdom, of which the Italian rye grass, the perennial rye grass, the meadow fox-tail, crested dog's-tail, the meadow cat's-tail or Timothy, the cock's-foot, the fescues (meadow, sheep and hard), meadow grass (smooth and rough stalked), and sweet vernal are the most valuable.

The clovers and trefoils, with vetches, are termed artificial grasses. They have been given this inaccurate name to distinguish them from the true or natural grasses. There are nearly twenty species of clover, belong-

ing to the flora of Britain, and the most important of these is the red, of which there are two classes, the biennial, and the perennial. They are both very valuable as forage crops, giving two, three, or four cuttings in the year. It is not much more than 100 years since clover was introduced as a field crop. It is now generally grown in rotation with grain crops. Cow grass is hardier and coarser than red clover, being better suited for pasturage, coming up better after being cropped by the animals. The Dutch or white clover is better suited for pasturage than forage. It grows on a variety of soils, but is peculiarly suited to limestone districts. The yellow clover is sown in cases where the red or white do not get on favourably. When it is mixed with other clovers a good pasture is formed, as it comes up early in spring. The soil should be thoroughly cleaned previous to being put down in clover, for the weeds cannot be removed while this crop is in the ground. It is sown with the barley or winter wheat early in the spring. Farmyard manure answers very well for clover, and when well manured the plants do not die out in spring.

Lucerne, another leguminous plant like clover, is perennial, giving good crops for several years. The produce is great, and it is ready for use earlier than any other artificial grass in spring. It may be mown several times every

year, excepting the first, and should be cut before flowering so that it may not become fibrous, and less nutritious and succulent. The flowers are blue or purple and racemose, and the stem is erect. It will give a profitable return for upwards of eight years and attains its greatest perfection in the third. It may be sown broadcast or in drills about the middle of April.

Sanfoin is another leguminous plant, with white or purple red flowers in racemes. It is a perennial plant, having leafy, stout stems, growing in dry pasture land. It is a useful forage plant, especially where sheep are kept. It may be sown either by itself or with corn crops, like clover. It is most productive in the third year, and may be allowed to remain for pasture for nine or ten years. It will give between one and two tons per acre. It is mown once a year and then grazed by the stock.

The vetch is another leguminous plant, cultivated to a considerable extent as fodder for cattle. It has blue, purple, or red, racemous, axillary flowers in pairs. When sown in the autumn it is ready for fodder early in summer, so that turnips may follow. In this case it is what is termed a stolen crop. It is sown broadcast, and covered in with a harrow or in drills. The manure is also drilled in sometimes as well. The growth of the plant is much increased by the application of one or two

hundredweight of Peruvian guano or eight or ten tons of farmyard manure. The summer vetch is sown in spring and early summer, and by sowing at different portions of the year a continuous supply of fodder may be produced for the stock. Oats is usually sown with the vetch in order to give it support, and prevent it lodging and rotting with the rain.

Of the grasses above-mentioned the meadow fox-tail and the smooth-stalked meadow grass are of medium quality, while there are many others not mentioned that cannot be profitably cultivated. The grasses usually contain from 70 to 80 per cent. of water; from 10 to 20 of carbo-hydrates, including starch; from 5 to 15 of woody fibre; and about 1 of fats.

The Italian rye grass and the perennial are so much alike that the one is mistaken for the other. However, the Italian grows more in tufts that the other, and hairs are attached to the seeds. It will produce more forage than any other grass, giving four heavy cuts during the year, which may in exceptional cases yield between 30 and 40 tons of grass, equal to 6 or 8 tons of hay when cut before flowering. But the yield depends upon the soil, the cultivation, and the manuring. Italian rye grass differs from many other crops, since it can be forced to almost any extent without detriment to the plant, whereas other crops suffer from over-luxuriance and too much manure. For instance,

as many as seven crops of this grass have been obtained from even poor soils by the liberal application of sewage. It is generally sown with corn crops, and a portion of it is cut down with the corn at the harvest that much enhances the value of the straw for feeding purposes. Where the soil is rich the grass grows so luxuriantly as to prevent the free circulation of the air among the stems of the cereal crop, and at other times when the corn lodges the grass is spoiled. In order to remedy these drawbacks the grass is sown by itself immediately after the corn has been cut down and the stubble broken up, so that it may come up sufficiently strong to withstand the frost. It is thus the only grass that is sown by itself, taking the same place in the rotation as clover. The second year's crop is not so heavy and profitable as the first, and it therefore becomes a question of soil, climate, and other circumstances, as to whether it may be allowed to stand for a second year.

The perennial rye grass is very generally cultivated, growing well on even poor soils, and will give when cut before flowering two or three crops in the year. It is not really a perennial grass; one variety of it, called the annual, may last for two years under favourable circumstances. The best kinds are profitable for two years, but die out afterwards. For this reason it is often sown with the permanent grasses, as

it gives a good crop until the others are fully developed.

The meadow fox-tail forms a considerable proportion of the valuable grasses in good pastures. It is one of the earliest, and is relished by cattle and sheep. It comes to perfection in three years, and its succulent broad leaves are soon renewed after being eaten down.

The crested dog's-tail has deep roots and can withstand the drought. When allowed to grow too long the stems become wiry and unfit for sheep or cattle, but when kept grazed down the root leaves are appreciated by the stock. The roots are tufted, and the leaves are slightly hairy and almost filiform. It is not a grass of average quality.

The meadow cat's-tail, or Timothy grass, flourishes better than most other grasses on strong clay soils, being very well adapted to moist deep land, and succeeds pretty well on moorland. In laying down grass land it should be mixed with other seeds. Its chief defect is that the aftergrowth is rather light. It is a perennial, and will grow at the height of 1,300 feet in the North of England. This grass produces excellent fodder, flowering in July, and having flat, short leaves.

The cock's-foot is a valuable pasture grass, growing at the height of upwards of 1,500 feet in the North of England. It is a

perennial, flowering in June or July, and has coarse, flat-keeled, long, strong leaves, of a dark green colour, that grow rapidly. This grass is nutritious and productive, and its coarseness is rather apparent than real. When grazed by stock for about six years it dies out; however, it should be mixed with other grasses for pasture, inasmuch as it not only forms good forage, but also gives support to the more tender ones, keeping their foliage from rotting on the ground. It will grow on all soils, excepting on those which are very light and waterlogged.

The hard fescue is a very hardy and productive grass, growing at the height of upwards of 2,500 feet in the Highlands. It is, therefore, very suitable for mountain pastures, and a great variety of soil, even thriving well on light, dry land, bearing the summer dry weather, and retaining its verdure in the winter, and therefore forms a good grass for lawns.

Sheep's fescue is an arctic grass, growing at the height of upwards of 4,000 feet, and is therefore especially adapted for mountain pastures, forming a large proportion of sheep herbage. It has fine bristly leaves, growing in tufts usually to the height of a few inches, producing good mutton, but it is not so productive as other fescues. The smallness of the leaves adapts this variety for pleasure grounds or lawns.

The meadow, like the other fescues, is a hardy plant, growing at the height of upwards of 1,500 feet in the North of England. It grows well on the banks of rivers and streams, and in moist places, but is unsuitable for dry, light land. It is a rich pasture grass, being very productive on meadows having a rather moist soil. The stalks are coarse, the leaves flat, and much appreciated by cattle and horses.

The smooth-stalked meadow grass grows to heights ranging between 2,000 and 3,000 feet in Great Britain and Ireland. The stem is stout, smooth, cylindrical, and tapering, with linear, flat, acute leaves. This plant has creeping roots, suitable for mixing with other seeds for land too light for the more valuable grasses.

The rough-stalked meadow grass is distinguished from the smooth-stalked by its rough stems and sheaths and erect panicles. It is a more valuable grass than the smooth-stalked, being usually found in good pastures, and is very productive on moist rich soils, especially when the land is irrigated. It cannot endure the drought and heat of summer, during which season it succeeds under the shades of trees or in woodland pasture. In Scotland it grows at the height of upwards of 2,400 feet. It forms a good mixture with some of the other valuable grasses.

Of other grasses the mat and sand are

useful for binding loose, sandy soils; the fiorin grass is especially adapted for reclaimed bogs or salt marshes; the water grass for wet land, pools, and ditches; and the wood meadow grass for growing among trees.

The yield of grass, like most other farm produce, is much less than it would be if better systems of manuring and weeding were employed, and if the most productive grasses that are adapted to the soil and climate of each particular district were laid down. There are lots of farmers (the small especially) who reduce the land by repeating corn and other crops, and then often allow it to cover itself with any kinds of grasses and weeds that may spring up. To produce good and profitable grass the soil should be properly pulverized, genuine seeds sown, and the land should be clean and rich, and if not so naturally it should be improved by proper methods. The grass and clover seeds are usually sown with corn crops, especially barley or oats, and sometimes with wheat, with which they do not succeed so well on account of the stiffness of the soil, &c. Sometimes the grasses are sown by themselves for permanent pasture, and especially after one or two manured crops good grass is produced.

CHAPTER XIX.

HAYMAKING.

THE stems and leaves of the grasses and clover form, when cut and dried, a very nutritious fodder for cattle and horses. The hay harvest in the grazing and dairy farm districts, and in the vicinity of towns, is of equal importance with the corn harvest. In England a great deal of hay is made from the natural and other grasses of the meadows, but in Scotland it is principally made from rye-grass and clover. In haymaking, as in many other farm operations, there is a great loss of produce by bad management and bad weather, and it is often difficult to say which causes the greater loss of value in the hay. The English farmer conducts the processes of haymaking in a far more satisfactory manner than either the Scotch or Irish, producing hay of much greater value. It is very often allowed to remain in cocks so long in the field that the growth of the grass underneath is checked, or altogether destroyed,

and the hay more or less spoiled. Rain depreciates the value of hay to a greater or less extent, according to the quantity that falls during the haymaking process. More or less of the soluble constituents of the hay are dissolved and carried away by the water. And when it ferments the coumarine, the volatile organic principle, which gives the fragrance, is dissolved by the alcohol in the presence of the water (rain), the odour being dissipated, and its value lessened to a great extent as an effective food. This coumarine is found in the sweet-scented vernal grass, which should always be introduced to a limited extent in any mixture of grasses for making hay. This organic compound is only slightly soluble in cold water so that the rain, unless the hay is undergoing fermentation simultaneously, does not do much injury. Boiling water dissolves coumarine ($C_9H_6O_2$) very freely. In good hay this compound increases the secretion of saliva in the salivary gland, thus enabling cattle and horses to extract and assimilate more nutriment from the same quantity of food. Again, the chlorophyll, or colouring matter of the grasses, is liable to be separated by the alcohol. This principle, when the hay is allowed to remain too long in the field, becomes oxidized, so that the green colour, which should as much as possible be preserved in the hay, is destroyed. But if the hay is ricked too soon, fermentation is induced,

by which both coumarine and sugar are lost to a greater or less degree. It therefore requires considerable judgment to steer clear of this Scylla and Charybdis of haymaking. The various grasses for hay should be cut when in full vigour and bloom, for, if allowed to grow much beyond this point, woody fibre will be formed at the expense of the sugar in the grass, and the nitrogenous matters will go to the seed, so that its value will be very much reduced in a dietary point of view. And when the grasses are mixed they should be cut when there is the greatest amount of bloom. It is best to cut clover when in full blossom. The hay is then dried by tedding it out on the field, and when the wind and sun are favourable it will be ready to rick on the second or third day, but the proper time to lie out in every case depends so much on the weather and other causes, that no general rules can be laid down. The flavour of hay is usually considered to be improved by a certain amount of heating or fermentation, and is more relished by horses and cattle, aiding digestion. But when it becomes overheated by imperfect making or taking up too soon, it becomes almost black, the value as food being very much diminished, and fungi produced, that have an injurious action on animals. This dark hay may cause abortion in cattle, and it increases the secretion of urine in the horse. When given to stock it

should be mixed with much straw either whole or cut. From 10 to 20 lbs. of salt when sprinkled over each ton of hay serves to prevent fermentation, by the magnesic chloride present in the salt absorbing moisture; it also destroys fungi, and insects and their eggs, as well as supplies this useful and necessary condiment (salt) to the stock, rendering hay that is too much weathered and injured by rain more palatable.

For sheep and horses clover-hay is the best, as it contains more albuminous matter than other kinds, and the ordinary, well made English hay is much esteemed for dairy cows. Care should be taken that the hay should not be stacked when wet, for it moulds although it does not ferment. And means should always be taken to ventilate the haystack, by making openings that communicate with the external air, so that fermentation may be checked.

CHAPTER XX.

ORCHARDS AND FRUIT GARDENS.

ORCHARD is the name given to a portion of ground devoted to the growth of fruit trees so closely planted that there is no space for the production of vegetables. The trees are usually planted in rows, running north and south, and often upon ridges. The soil should be dry and slope more or less towards the sun. The orchard should be surrounded by a hedge which should not be very high if the grounds are small, and forest trees should be planted so as to afford shelter from the prevailing and cold winds.

Sheep and cattle are often pastured in orchards, the land having been ploughed, the trees planted and then sown with grass seeds, or the trees have been planted on pasture ground, the turf being replaced round the trees afterwards. In this way the grass is converted into manure, increasing the fertility, and additional manure is sometimes

applied. In these grass orchards standards and half standards are planted, so that the cattle may not be able to damage the branches. But in orchards from which the most fruit is derived dwarf standards are planted in rows about 12 feet distant, with gooseberries, raspberries, or currant bushes interspersed. When these orchards are liberally supplied with manure, and properly cultivated, they are very productive, and are not liable to be damaged to any extent by winds.

Orchards are a common appendage of the English farm-houses, and in Hereford, Devon, and other southern counties they are often of large extent, containing apple trees cultivated for the production of cider, and pears to a less extent for perry. The stocks are usually first planted, and they are grafted or budded afterwards. Figs are cultivated to some extent in the southern counties. But the usual fruits cultivated in orchards, besides apples and pears, are cherries and plums, and sometimes chestnuts, walnuts, mulberries, medlars, &c.

The soil for fruit grounds should not be so clayey as to retain too much moisture, neither should it be so sandy or porous as to retain too little or none at all in dry weather. It should be medium soil, neither too retentive nor too porous. If it is too retentive, it may be made less so by the application of sand, ashes,

mortar, or lime, turf, weeds, or any kind of vegetable matter. If too sandy or porous, it can be rectified by the addition of clay, marl, mud, weeds, turf, &c. Holes should be dug of about 6 feet square and 2 feet deep if a dry soil, and 1 foot if wet or damp, with an allowance of 4 or 5 inches for a floor of stones, brick bats, &c., to prevent the roots going downwards, and to secure drainage. A corrective to the staple soil of the garden may be made by introducing into this hole, round and above the roots, sandy loam and plenty of turf and vegetable matter, and if the staple is sandy, clay will do well.

In selecting a piece of ground for a fruit garden, preference should be given to any portion sloping towards the south-east and south-west, and the intermediate points; a south-south-west aspect being probably the best. Near the walls of the garden there should be groups of firs, beech, holly, and other trees, to shelter from the cold winds proceeding from the north-west and north-east and the intermediate points.

The varieties of cherry, with greengage plum, may be grown along the wall having a northerly aspect, cherries and pears may be grown with a western, and pears and plums with an eastern, while the peach and nectarine with the apricot may be planted along the wall with southerly aspect. The vine will

succeed only in the south of England with this aspect. The width of the border along the wall should be 6 feet, which will be sufficient to allow space for the roots of the fruit trees next the wall, and along the border next a walk—say 4 feet in width—there will be space for fruit trees on trellises alternating with the others; and on the other side of the walk there might be rows of fruit trees of either pyramidal or dwarfed growth.

The form of the garden should be, if possible, that of a rectangle or parallelogram, in order to have as much exposure as possible of wall for fruit trees. Two walks should cross each other in the centre of the garden at right angles, and along these walks currants, gooseberries, and other bush fruit may be grown. If vegetables are to be grown the wall border must be 10 feet wide instead of six. Perhaps it is better, however, to grow the vegetables on a separate part of the garden.

Walls built of brick especially are much better than hedges, that take a considerable amount of nutriment from the soil, as well as harbour snails, birds, &c.

Fruit trees are usually planted in the early autumn, when the ground is in good condition, but, if not, they may be planted not later than the middle of March. In planting, the roots should not be too much exposed to the air and heat, neither should they be placed so deep as

to be beyond their influences. It is sufficient if the roots are covered so as not to be exposed directly to the air. When the soil is a retentive clay the tree may be placed with its roots spread out on the surface, and a mound of some compost suitable to the plant formed, just covering the roots. In this case, as the tree has no firm hold on the ground, it should be supported by stakes, to which it is attached by straw ropes. When the tree is planted in the soil the roots should be spread out like the spokes of a wheel from a common centre, and covered with a fine mould, which should be gently pressed down about the roots but not rammed so as to mutilate or destroy them. A top-dressing of partially rotted manure or other organic matters placed on the surface just over the roots will supply, on the application of water naturally or artificially, a weak liquid manure that will be very beneficial, and will also encourage roots upwards instead of downwards into the subsoil. This application of manure by retaining moisture about the roots is very useful in dry weather and upon sandy or light soils. It also reinvigorates old trees, supplies heat and moisture to newly planted ones, and moisture as well as food to plants on dry and poor soils.

Grafting in the case of plants is analogous to crossing in the case of animals. In the breeding we must not cross an animal of one order

with that of a different one, such as a horse with a cow, neither should we put together animals of the same kind that are very dissimilar, such as a cart horse with a race horse; so in grafting we must not fix a scion of an apple tree on to an oak, and with those plants belonging to the same genus those species should be selected which are not very dissimilar, for grafting cannot be performed with a scion that belongs to a different natural family from the stock.

It is important in grafting that the alburnum (or the woody layers most recently formed, still having their tubes open for the passage of the nutrient fluids) of the scion should be in contact with that portion of the stock, for the hardwood of the one will never unite with that of the other, as the tubes in this part have been closed, so that a common fluid cannot pass from the one to the other forming a bond of union. The scions are usually taken from the shoots of the previous summer and grafted on to the stock just when the sap begins to circulate. The best results are produced when the scion is taken from the extremities of the lateral rather than the higher and more perpendicular branches, and from fruitful and healthy trees rather than the reverse. It is also well to keep it a day or two before grafting.

There are various methods of grafting, termed

whip or tongue, *cleft*, *crown*, *shoulder*, *saddle*, and *peg*.

In whip or tongue grafting, the scion and stock are cut obliquely, and angular incisions are made in both, and the tongue of the scion is inserted into the cut in the stock. This kind of grafting is practised when the scion and stock are of about equal sizes, or for young trees in nurseries.

In cleft grafting, the head of the stock is cut off obliquely, and cleft down for about two inches, and the scion, cut into the form of a wedge, is inserted into the cut. This kind of grafting is practised when the stock is much thicker than the scion, when the scion of a new variety is introduced into large branches, and when the object is to increase fruitfulness.

In crown grafting, two scions are inserted close to the bark, in two cuts at right angles to each other in the stock.

In shoulder grafting the scion and stock are made to fit by cutting them obliquely and then across to form a shoulder. This method is used in grafting ornamental trees.

In saddle grafting the scion is slit up so as to fit on each side of the wedge-formed stock.

In peg.grafting, the end of the scion is made into the form of a peg to fit into a hole in the stock.

Budding effects the same object as grafting, in another way, at another time of the year. A bud is taken from a young shoot in August or

the beginning of September with a sharp knife, so that there is about half an inch of bark above and below it. The wood is removed, so that there is only the axis of the bud and the bark, which is inserted under the bark of the stock by cutting it down to the wood transversely and perpendicularly in the form of the letter T. In less than a month's time the bud will have established itself, and the soft matting with which it was bound may be loosened, but not removed for another month.

In grafting, the access of air to the cut is prevented by covering over the juncture of the scion and stock by grafting clay, wax, gutta percha, &c.

Grafting clay is made by working up some clay with horse and cow dung thoroughly. This is applied in the form of a ball to the juncture tapering upwards and downwards, and a finished appearance is given to it by dipping the hands into some fine ashes and applying them round the clay composition so that no air can possibly obtain ingress.

The grafting wax is prepared by melting equal weights of mutton fat and white wax, and adding gradually the same weight of red sealing wax as white, with one-eighth of the weight of honey, before taking off the fire.

The apple will grow on various soils, some varieties succeeding in clay soils, some in peat, if well drained, and others in sandy soils.

The pear succeeds on clayey loams, sandy

chalkey or gravelly soils, but the quince stock does not thrive on sandy but gets on best upon alluvial or prepared soils.

The plum (damson) succeeds well in the north-western counties on sandy loams. Clays and peats, and a good free loam, will answer for most of the varieties of this fruit.

The peach and nectarine, being two varieties of the same species, succeed in the same kind of soil. In planting the roots should be well bedded with a mixture of old humus and loam, and then the ground soil mixed with some decayed leaves or partially rotted manure placed above.

The cherry thrives best on a sandy loam, but it succeeds pretty well on other soils.

The apricot will thrive best on a friable loam manured with a mixture of soils, with a fourth of partially rotted leaves. A platform of bricks should be placed underneath each tree.

The gooseberry may be planted in the ordinary garden soil by making a trench and covering the roots with less than 2 inches of earth, then an inch of well-rotted manure and soil over this will do.

The currant will grow on most moist soils, and does not thrive on sandy and hot ground.

The raspberry thrives best on a rich, light soil, or on a good loam, deeply dug or trenched, and leaves, weeds, and some partially rotted manure placed at the bottom of the trench.

The strawberry succeeds well on a sandy loam that is deep and light, with a clean, red sandy subsoil; but this plant will require, especially in dry weather, watering or mulching, or both.

Nuts will thrive on a light loamy soil, that is more sandy than clayey. A rich soil will not produce the female flowers.

The fig will succeed on almost any kind of soil provided it is drained so as to become sufficiently porous to allow water to pass through, while it retains sufficient moisture during dry and hot weather. Watering will rectify drought. If the garden soil is too porous and light it may be corrected by mixing with loam, and if too retentive of moisture the addition of sand and ashes will remedy the defect.

The vine will not succeed when the subsoil is moist, hence clay soils are not so good as porous, light sandy ones. When the subsoil is saturated with water means must be taken to drain it away, and a sole formed under the plant with slates, tiles, &c., with broken stones and a layer of turf over. Lime or charred rubbish, decayed leaves, and partially rotted manure may also be added. The vine grows most luxuriantly on deep, rich land, but the quality of the fruit is not so good as when grown on other soils.

The apple tree is best adapted to the cold part of the temperate zone, and when found

beyond these limits its fruit is not so good. The finest kinds will only succeed on a good soil with a fine climate, but the hardier sorts will bear a considerable amount of cold and exposure. The apple tree is to be seen even in some parts of Arabia, Persia, and the West Indies, but in these countries it suffers from excess of heat. There are about ninety constant varieties with many sub-varieties, which vary more or less in their adaptation to soil and climate, but, as a rule, the fruit tree requires a sheltered situation and a fertile soil.

The pear belongs to the same genus as the apple, and they are usually adapted to the same climate. It is found wild in the temperate parts of Asia, Europe, and even in Great Britain.

The English climate as well as that of many parts of the Continent are suitable to the cultivation of the plum and its valuable varieties, such as the greengage, the damson, the bullace, &c.

The peach and nectarine are virtually varieties of the same tree produced by cultivation, the only difference is that the fruit of the latter is smooth, while the former is downy. The peach belongs to the temperate regions, and is a native of the North of India and Persia. It is cultivated in the warm temperate parts of America, Australia, Europe, &c. In this country it is trained on walls, and in

colder parts on flued walls and even in hot-houses.

The cherry belongs to the same genus as the plum, or is rather a sub-genus. It is grown in Western Asia and all over Europe, and even in the north of Scandinavia it ripens its fruit. There are many varieties peculiar to certain soils and climates.

The apricot also belongs to the same genus as the plum. It is native to certain parts of Central, East, and West Asia. It is cultivated in Western Europe, and in the south of England as a standard, but in the northern countries as a wall tree. The *Breda* is the favourite variety in South England as a standard, and in Scotland as a wall tree, but the Moorpark is usually considered the finest variety.

The gooseberry belongs to the same genus of plants as the currant, and is distributed over the north-west Himalayas, North Africa, Europe, the north of Asia, &c.; it grows wild in thickets, and rocky, and mountainous districts. It also grows in hedges in this country, but it is doubtful if it is a native. By cultivation very many varieties are produced, and the weight, especially in Lancashire, where it is cultivated with the greatest success, has been doubled and even trebled.

There are two principal varieties of currant, the red and black, but there is a yellow variety grown in Russia. It is found wild in the south

of Europe, and parts of North America and Asia, in woods and thickets; but it is very doubtful whether it is a native of Great Britain. It is cultivated in the Netherlands, Germany, and especially in France, to a great extent, where about a quarter of a million of gallons of a liqueur is prepared from it. The black currant is extensively cultivated in the north of Scotland, even in the Hebrides and Shetland Islands. The size of the red or white variety has been very much increased by cultivation lately.

The raspberry is found wild throughout Europe, North Africa, Siberia, and Western Asia. In Great Britain it is found in woods, especially in mountainous districts, reaching to a height of upwards of 1,800 feet in the Highlands of Scotland. By cultivation the size of the fruit has been much increased. The plant is most easily multiplied by means of suckers. It succeeds better in the shade than when exposed to the sun's rays.

The strawberry is a native of North and South America, and other varieties are peculiar to Germany, Switzerland, and even the Himalayas. The wood strawberry is a native of Great Britain. By cultivation the fruit has attained a large size, but great care is required to prevent the finer and larger varieties from degenerating.

There are many varieties of nuts, such as

filberts, cobs, chestnuts, walnuts, &c. The walnut will not ripen its fruit except in the warmest parts of the South of England.

The chestnut is only planted for fruit in Devonshire and some other parts of the South of England.

Filberts and cob-nuts are the names given to the cultivated varieties of the hazel-nut, which s a native of Great Britain and the temperate portions of Europe, Asia, and North America. Large quantities of these nuts are produced in England, especially in Kent.

Almost the whole of the numerous species of the fig are confined to tropical and sub-tropical countries. It is a native of Asia, especially India, but it is now cultivated in the south of Europe, and in various parts of the United States. It can only be grown as a standard in some favoured situations in the south of England, where there are a few fig orchards. Of course it can always be grown in hot houses. It will ripen against a wall in favoured situations even in the north of England and south of Scotland.

The vine is cultivated in many parts of Asia, Europe, America, Africa, Australia, &c., but its native *habĭtat* is usually considered to be the hilly districts south of the Caspian Sea, from whence it was introduced into the south of Europe. It is largely cultivated in France, Spain, Germany, &c., from whence large

quantities of wine and brandy are imported into this country. It does not ripen its fruit in the north of England, and even in the south it is not always certain to succeed. When the climate is moist, or there is a considerable rainfall, it will not succeed.

The unfruitfulness of fruit trees is usually due to the cultivation immediately round the stem, by which the roots are mutilated or partially destroyed, and the plant has to reproduce fresh fibres to counteract this. When the tree is young and vigorous it can bear a certain amount of root mutilation, but as it becomes older the vital action gradually diminishes, so that sufficient fresh fibres are not formed, and unfruitfulness is the result. Again, when the soil is rich, or has been excessively manured, the tree obtains an excess of food whereby an over-luxuriant growth is induced, the plant rapidly increases in size by the formation of woody fibre, and little or no fruit is produced. By digging a trench round the roots towards the end of August or beginning of September, and cutting off all those roots penetrating deeply into the soil or that are longer than the others, this quick growing may be checked, particularly if stones or brickbats are placed so as to prevent the roots extending downwards before filling in the earth round the root again. The fruitfulness of fruit trees may often be increased by a judicious pruning, and by cutting off a con-

siderable portion of the top when it is found that the fruit on this part is much superior to the rest. The blossoms of fruit trees may be protected from injury by the frosts by shading the trees during the day from the early spring sun, and exposing them during the night to prevent early blooming. And when the trees have blossomed a netting or canvas should be stretched over them at half a right angle during the night, and removed from eight or nine o'clock till, say, four in the afternoon. Some people protect the blossoms by overhanging boughs of trees and fronds of ferns, but this plan is more or less objectionable.

Fruits, when immature or in the green state, decompose, like leaves, carbonic anhydride in the sunlight, absorbing the carbon and setting free the whole or portion of the oxygen. When one atom of oxygen is set free from two molecules of carbonic anhydride we have C_2O_3, which with water forms oxalic acid, from two molecules of which, by the addition of one molecule of water and the elimination of four atoms of oxygen, malic acid is produced; and if three atoms of oxygen are set free instead of four, tartaric acid is formed. Malic acid is found in the apple, tartaric acid in the grape, and the various acids in other fruits are formed similarly. Fruit sugar is formed by the combination of six molecules of water with six of carbonic anhydride, with the elimination of

twelve atoms of oxygen; or it may be formed by the addition of a molecule of water to starch, which is also formed from water and carbonic anhydride with the elimination of oxygen. When the fruit becomes more mature the outside becomes harder, ceasing to perform its vegetative functions. Other fruits, again, in ripening absorb the oxygen and evolve carbonic anhydride. The various compounds produced in fruits are extremely varied, but they are all produced from carbonic anhydride, water, ammonia, phosphates, sulphates, and the other various mineral constituents of the soil.

The fruits in the table contain the following percentage of constituents :—

	Apples.	Pear.	Grape.	Gooseberry.
Water	85.00	84.00	80.00	85.30
Sugar	7.60	7.00	13.75	7.50
Acid	1.05	0.10	1.00	1.30
Albumen	.23	.25	.85	.40
Pectine, &c.	2.75	3.30	.50	2.10
Minerals,	.45	.30	.45	.25
Insoluble constituents, seeds, stones, skins, pectose, minerals, &c.	2.92	5.05	3.45	3.15

From this table it will be seen that the percentage of sugar is greatest in grapes, hence their vast superiority to other fruit in the pre-

paration of wine, and in some grapes the percentage amounts to upwards of 25 per cent. In pears the sugar is from 70 to 90 times more than the free acid, but in the apple it is only from seven to twelve times greater, and in the grape from fourteen to more than twenty times. In the apple and pear, and especially in the peach, there is more pectine, the substance that gelatinizes on boiling these fruits. The very varied tastes of the different varieties of apples and pears are due to the different proportions of sugar, acid, and pectine.

Some idea of the value f fruit and its produce may be formed when we consider that about two millions and a half sterling are spent annually upon that imported, and nearly six millions sterling upon imported wine, the produce of the grape.

From most fruits drinks are made; thus from the vine, wine and brandy are prepared; a pleasant wine from the plum, and a spirit by distillation; peach brandy and peach water from the peach; a liqueur from the cherry; from the gooseberry and raspberry wine and vinegar; wine, not inferior to that of the grape, is well made from the currant; perry from the pear, and especially cider from the apple are prepared to a considerable extent in various parts of England. Small apples produce a better result in the preparation of cider than large ones, since there is more bulk of seeds,

proportionately containing more albumen, which has a considerable influence upon the strength of the resultant liquid. In grinding, the seeds should therefore be thoroughly bruised, so that the albuminous matter may be utilized. The longer the apples are allowed to remain on the tree without exposing them to frost the better is the juice matured, and the fermentation is more quiet. The slightest elevation of temperature is sufficient to set up a rapid fermentation, as the proximate elements of which the juice is composed are so feebly held together. They should, therefore, if possible, be gathered without wounding them in cold bracing weather, and placed in heaps in a cold place outside or in a cool room, to ensure the gradual development of saccharine matter. Acid and sweet apples may be ground together or separately for cider. The grinding should be performed near the close of the year in cold or frosty weather so as to prevent too rapid a fermentation. They are crushed under a cylindrical stone or between rollers, and the resultant pulp is put into horsehair cloths piled above each other, and the juice squeezed out into a vessel. The density of the juice should be about 1070; if less, sugar, boiling or freezing will increase it. Rapid fermentation is prevented by a simple process termed sulphurizing; only about one-fourth of the sugar in the juice should be fermented, and this may be

attained by reducing the gravity from say 1080 to 1060. The cider, if well made, should be of a fine amber tint. The pale tint usually denotes defective fruit. By the addition of chips of log-wood the tint may be rectified. Cider contains about 7 per cent. of alcohol, but soon becomes sour by the formation of lactic acid. Cider is prepared in Gloucester, Hereford, Worcester, Devon, and other parts of the country, and perry is also prepared in the same districts from those pears that are not so pleasant for eating. This beverage is made in much the same way as cider, and contains about the same percentage of alcohol.

The various drinks, preserves, &c., that are made from fruits are only methods of keeping their principles for a longer time, since they are usually very liable to decomposition, which destroys their value altogether.

In order to preserve fruits in their natural state, they should not be exposed to the air, particularly stagnant or moist air, neither should they be subjected to frequent or sudden changes of temperature. In order to exclude the air, fruit is often packed in vessels with sawdust, dry sand, bran, &c., and the application of a gentle heat expels any moisture that may be present, and burying the vessels in the earth ensures an equable temperature, so that they may be preserved for a long time.

Gooseberries, &c., may be preserved in this

way, and so may grapes, which are imported packed in sawdust. Apples may be kept in a fruit room provided with drawers and shelves, kept dry, and at an equable rather low temperature, with proper ventilation; and pears may be kept in the same way, especially if they have been gathered by hand, but they keep better in a cool place in earthenware jars, in which they are packed so as to be separate, when an unsound pear will not affect another.

CHAPTER XXI.

WOODS AND PLANTATIONS.

WOODS and plantations have attracted more attention in England within the last few centuries than formerly, and it is only about a century since the cultivation of trees became general in Scotland and Ireland. In Germany especially, in France and other European countries, natural forests are systematically and scientifically managed, so that an abundance of fuel as well as an increase of valuable timber is obtained. In Great Britain the cultivation of trees in woods and plantations is often found to be more remunerative on certain classes of soil than the utilization of the land for other purposes, especially when they are carefully managed. Considering that about fifteen millions sterling are spent upon imported timber, it is evident that there is plenty of scope for its increased production. The attention that has hitherto been given to the production of timber has been but slight. The

connection between the tree and the climate and soil has not been sufficiently studied by those who are engaged in the practice of arboriculture. The consequence is that trees are often planted in unsuitable situations. Some trees delight in moist climates, while others do not; some will only succeed in rich soils; some trees require shelter, while others will bear considerable exposure; some will stand the sea breezes, while others cannot.

As trees usually will not thrive in moist soils, the first step towards the formation of a plantation is to drain the land. Trees having deep roots require to be placed higher above the rise of the water in the soil than surface-rooted ones. The cultivation of plantations is in this country beneficial rather than otherwise, but where there is an excess of trees in any part of the country injurious influences are produced, causing unhealthiness in man and other animals. When trees are judiciously planted they afford a certain amount of shelter, which has a very beneficial effect upon the cultivation of other crops; although forests, by condensing the moisture of the air, increase the wetness of the district. However, the roots dry the soil in their immediate vicinity, and when the trees are cut down water accumulates. In this country trees are usually produced from young plants grown from seeds in a nursery, but on the Continent woods are generally raised

from the seeds directly. The methods of planting young trees are either by *slit* or *notch* and *pit* planting. The slit is principally practised in Scotland and the pit planting in England. The slit planting is done by means of a hand iron or a planting spade, which is thrown into the ground slantingly and the roots of the young tree inserted. In this way a man may plant upwards of 3,000 young trees in one day. The larch and Scotch pine are usually planted in this way. The planting of the broad-leaved trees is much more expensive, since they are usually planted in pits.

Trees are generally divided into the *coniferous* or the *needle-wood* of the Germans, the pines and firs, and the other the *leaf-wood* of the Germans, commonly divided into the hard- and soft-wooded trees. The ash, beech, birch, chestnut, elm, oak, sycamore, and walnut are hard, and the alder, horse-chestnut, lime, poplar, and willow are soft woods. Most trees will succeed on a deep, loose earth, and most soils will grow at least several varieties of wood. The oak succeeds on a clay or deep gravelly clay, the roots penetrating the soil deeply ; and larch may profitably be grown with it, as it derives its nutriment from the surface soil. As about a dozen years must elapse before any profit is derived from a newly-formed plantation, it is evident that it should eventually be very remunerative, otherwise there would not be

much inducement to plant trees for pecuniary considerations. As it is usual, in the formation of plantations, to plant different kinds of trees, and many to act the part of nurses to those destined permanently to occupy the ground, the nursing trees—larch, spruce, birch, and fir—are gradually cut down from time to time in the process of thinning, those affording the earliest return of profit upon the original outlay. And when once the process of cutting down has commenced it is continuous, so that periodic profits are obtained, but the thinning should be very gradually performed, otherwise the other trees become much more fully exposed to the weather, with disastrous consequences. In most cases a judicious thinning will be sufficient without resorting to pruning, which often produces bad instead of favourable results.

The hard-woods in a plantation should be planted 25 or 30 feet apart, the intervening spaces being filled up with larch, spruce, &c., which are useful after about eleven years' growth, but the hard-woods are of little value until they attain a good age. A very considerable return is sometimes derived from a copse or natural wood, the trees not being allowed to attain their ordinary size but are cut over from time to time, as they send up new shoots adapted to the purposes for which they are cut. In this way the oak is cultivated in various parts of England and Scotland for its bark,

being cut over every twelve or twenty-four years, the wood being used variously for timber, for spokes of wheels, &c., for firewood, or for charcoal. The osier and willow are cut over for baskets, the hazel for crates, the chestnut for hop poles, the ash for hurdles, hoops, the handles of tools, &c. The trees just mentioned, with the alder, birch, elm, maple, &c., send up new shoots on being cut over, but the fir, &c., refuse to reform them. In natural woods the ages and sizes of the trees vary very much, and the stronger and hardier prevail over the weaker, but the latter cause the production of cleaner timber by either preventing the formation of low side branches, or the weakening of their strength to a considerable degree. The longer certain trees grow their value increases in a greater ratio. Compared with the time, thus a certain area of elm or ash will, after sixty years, be twice as valuable as after forty years' growth.

All timber is more or less liable to decay, and various methods of preserving it have been practised. Timber driven into the ground has been charred, other timber has been painted and coated with tar, &c., to prevent decay, which is due to moisture, atmospheric action, and the attacks of parasitic plants and animals. By injecting into the pores of the wood a solution of corrosive sublimate the timber is prevented from rotting. By pouring a solution of sulphate of copper into a hollow at the top of a tree still

growing with its top off, the solution penetrates downwards, destroying the vitality of the tree, but confers upon the timber a lasting durability. Creosoting, or the application of coal tar, is also practised to prevent decomposition.

The ash grows all over Europe, the north of Asia, America, &c., as well as in this country, of which it is a native. It grows best in a loamy soil, but almost any other will do. In this country it will grow in elevated and exposed situations, in which many other trees would not thrive. The wood is characterized by great toughness and elasticity, and is prized by coach-makers, cartmakers, wheelwrights, turners, and carpenters. It sometimes grows to a height of about 150 feet, and is a fine tree for parks, but other vegetation does not succeed very well near it, as it takes a large amount of food from the soil.

The beech will attain a height of upwards of 100 feet, and a girth of more than 12 feet. The wood is of a brownish-red tint; it is solid, hard, but brittle, and on exposure to the air rots and is eaten by worms, but when kept under water it is very durable, and is therefore used for sluices, weirs, mills, and for wooden shoes, as it does not absorb water. On the Continent, where there are large forests consisting mainly of beech trees, it is largely used for firewood. The raspings of the wood are used to prepare vinegar, and the bark is sometimes used for

tanning. It succeeds well on light soils, the roots being confined to near the surface.

The birch scarcely ever exceeds 70 feet in height and a diameter of 2 feet. There are several varieties, as the white, the black, the yellow, the cherry, &c. It abounds in the northern parts of the old and new world, and in more southern districts in elevated parts. The sap of this wood is used as a drink and is also fermented. The wood being white, solid and tough, is much used by turners, coopers, wheelwrights, carpenters, &c. The bark is used as a food, for tanning, for making ropes, &c.

The chestnut produces a hard and durable wood that is much used for making furniture, for housebuilding, and various other purposes. It is largely cultivated in the south of Europe as it furnishes the staple food of the poor people in these districts. It thrives best in light dry land with a dry subsoil, accompanied by a rather dry atmosphere. The fruit, containing about 15 per cent. of sugar, is ground into a kind of flour from which bread is made, and the juice is sometimes fermented. In the south of England it produces fruit, but the north is too cold. The bark is used for tanning and the stems of the young trees are used as fruit poles.

The elm, of which there are many varieties, is spread all over Europe, Africa, West Asia, America, &c. The wood of the English elm is valued by carpenters (for its fine grain), ship-

builders, wheelwrights, machine makers, &c. The bark is sometimes used as a food when ground into meal; it is also used in the refining of sugar and in dyeing.

The oak is found in tropical and temperate regions in Asia, Europe, America, &c. The oak succeeds best in loamy soils that are rather dry or well drained, as this tree, like many others, cannot endure standing water. A slight touch of calcareous matter blended with the loam is rather beneficial. This tree has been known to live for a thousand years, and to attain a height of nearly 200 feet and a diameter of 8 feet. The timber is solid, very durable, and capable of withstanding moisture, being used for ship-building, mill work, and in carpentry. The acorns are utilized as food, and the bark for tanning.

The walnut is found in Europe, Asia, America, &c. It sometimes grows to a height of 90 feet. The nuts of the walnut form a considerable part of the food of the south Europeans; sugar is obtained from the sap, and an oil from the nut. In England the fruit will not ripen, except in a few favoured spots in the south. The wood is very valuable, especially for cabinet-making, as it is fine in the grain, hard, and light.

The alder is found in the northern regions of the old and new world. It is a native of Great Britain, and delights in swampy and moist situations. The wood is of a yellow or

orange colour. It does not readily decay under water, and is therefore used for pumps, sluices, piles, millwork, &c. Alder charcoal is best suited for the manufacture of gunpowder, for which purpose it is often grown in copses. The wood is valuable for turnery and carpentry, and the bark is used for dyeing and tanning. It sometimes attains a height of 60 feet.

The horse-chestnut is cultivated in those parts of Europe where the climate is favourable. The wood is not characterized either by its durability or by its strength, but by its softness, which quality renders it valuable to the carver and turner. Horse-chestnuts are used as a food for stock. This tree is much used for ornamental purposes on account of its rich foliage and beautiful flowers. It sometimes attains a height of 100 feet, and the wide extending branches curve downward to the ground.

The lime tree is adapted to grow in North Asia, North America and Europe. The wood is characterized by its toughness, durability, softness, and lightness. It is used for carved work, pill boxes, and for turnery. Its charcoal is used for the manufacture of gunpowder, for crayons, &c. This tree is often planted in the streets of towns for to produce shade and coolness. The leaves when eaten by cows do not yield good butter.

The poplar is adapted to grow in cold and

temperate regions. This tree grows rapidly, and is very valuable for firewood, but it is not often of much value for any other purpose as the wood is soft and light. The wood of the white poplar is, however, used in toy-making, turnery, and in cabinet-making. The wood of the grey poplar is harder, and is used for carts, barrows, doors, flooring, &c. The poplar thrives in low clay soils. There are many varieties of this tree, having somewhat differing qualities.

The willow is adapted to grow in the cold regions of the northern parts of the old and new world, though some species are found in warm countries. It generally grows as a shrub. It succeeds well on the banks of rivers and other moist places. The wood of some species of willow, although soft and light, is very durable, and is used for steamboat paddles, and the twigs are used for hoops and in basket-making; and for these and other purposes, including firewood, it is frequently cultivated in copses.

The fir is sometimes used in a very extended sense, including the pines, but more frequently in the limited sense including the silver and spruce fir. The spruce fir attains a height of upwards of 170 feet, and is of a conical or pyramidal form, the branches being long at the base (and droop downwards as the tree gets old), gradually becoming shorter and shorter, so that the tree terminates in a point at the top. This wood is imported into this country under

the name of deal from the Baltic and Scandinavia. It furnishes spars and masts for ships. The tree yields turpentine, tar, rosin, lamp-black, spruce, beer, food, &c. There are several varieties of the spruce. The silver fir attains about the same height as the Norway spruce, but lives only 300 instead of about 400 years. It is adapted to grow in northern latitudes and the mountainous districts of Central Europe. The wood being white, soft, and light, is used by turners, carpenters, coopers, and for ship work. It is also peculiarly suited for the construction of the sound boards of musical instruments, and also for making bandboxes. This tree has been introduced into Great Britain. A variety of the fir, abounding in North America, yields Canada balsam, and the silver fir itself yields a valuable turpentine.

Pines abound in the northern hemisphere, and towards the tropics they are found clothing the sides and even the tops of the hills and mountains. The Scotch pine is the only one of the numerous varieties of pine that is indigenous to Great Britain. It lives to about the same age as the spruce, and is a rapid grower. This species grows on the mountains of southern Europe, and on the sandy coast soils of the north of Europe and Asia. The quality of the timber varies with the soil, the richer the land the worse the timber. The timber is

highly resinous and being durable on this account is used in ship and house building. It also yields lampblack, pitch, resin, tar, and turpentine. The North American pines yield durable and strong timber, used for ship building, &c.

The timber of the pine, including that of the larch, spruce, and Scotch fir, with the white pine of North America, are extensively used in carpentry on account of their softness, and the facility with which they can be worked with ordinary tools ; and this, combined with their lightness, strength, and durability, cause them to be used for house and ship building, &c. In fact, there is more pine timber used than that of all other kinds of timber put together. Nearly half a million tons of this timber is annually imported from Canada alone.

CHAPTER XXII.

WATER.

WATER is one of the most important compounds that exist in nature. Its existence is essential to plant and animal life. It forms about three-fourths of the weight of plants and animals. It is the most abundant substance on the earth, covering about three-fourths of its surface, in some parts to great and unknown depths. It is an essential part of plant and animal food, and by its agency other food constituents are carried through the vegetable or animal economy. Water is composed of the elements oxygen and hydrogen in the proportion of one of the former to two of the latter. By weight there is 16 of oxygen to 2 of hydrogen, giving 88.89 per cent. of oxygen and 11.11 of hydrogen, otherwise 9 lbs. of water contains 8 lbs. of oxygen and 1 lb. of hydrogen.

Water assists in dissolving and carrying along the particles of food through the body and continually into the blood. It assists in

carrying off the waste products of the body, and it keeps down its heat by escaping in vapour. Two quarts, or 5½ lbs., of water are required by a full-grown man daily in his food and drink. It quenches thirst, which is distinctly felt when the body loses 1 lb. of water. It forms a water-supply by falling in rain, mist, dew, snow, hail, and sleet. It wears away rocks, &c., and carries particles of matter to the sea.

Sea water is hard, and has a bitter taste. The salt prevents the water from dissolving soap.

In 100 parts of salt water there are about 3.44 parts of solid matter, made up thus—

Sodic chloride ($NaCl$)	2.4
Magnesic chloride ($MgCl_2$)	.4
Sodic sulphate (Na_2SO_4)	.4
Calcic Carbonate ($CaCo_3$)	.034
Silica (SiO_2)	.0086
Other substances	.2

Carbonic acid increases with the depth, air forms about $\frac{1}{30}$ or $\frac{1}{40}$ of its bulk, and there are traces of ammonia present.

The saltness of the sea varies, being greater in tropical regions and least in polar seas. Its specific gravity is about $\frac{1}{37}$ heavier than water, but it varies in every sea.

Distilled water is of a beautiful clear, pale blue colour, observed by looking through a long glass tube filled with it. It is 770 times heavier than air, and a cubic foot weighs 62½ lbs.

Each atmosphere produces a compression of $\frac{1}{20000}$ of the whole quantity of water. It has neither taste nor smell, and has a neutral reaction. It is composed of two of H and one of O, written thus, OH_2. When substances such as paraffin containing hydrogen are burnt water is produced. By exploding a mixture of two volumes of hydrogen to one of oxygen by an electric spark it is produced, and by the electolytic decomposition of water O and H are formed. A temperature of 2,800 deg. is produced by the combustion of H and O. Distilled water is produced by vaporizing water and condensing the steam.

Rain water is generally flat, often unwholesome to drink, and smoky in appearance and taste.

It is wholesome when collected in the country in clean vessels, but in towns it collects impurities such as floating particles of matter, and gases such as the offensive effluvia about towns, and nitrogen, oxygen, carbonic anhydrides and ammonia from the air.

The rainfall in London is about 25 inches, and in the north-west of England and Scotland 75 inches; 2,500 tons of water per acre fall in London, or 14 gallons on every 20 feet square daily. Rain water takes up vegetable matter, lead, zinc, &c., from roofs.

It contains about 1·59, ·85, and 0·6 per cent. of nitrogen, oxygen, and carbonic anhydride respectively.

Rain water receives impurities from passing over and through the land from manures, animal and plant refuse, sewage, foul liquid from factories, &c., which are undergoing putrefaction, that induce hurtful changes when taken into the stomach. These waters even sometimes contain poisons that generate contagious diseases.

However, the oxygen of the atmosphere oxidises and renders harmless to a great extent river water which contains less soluble matter (about ·05 per cent.) than spring water, and it is principally derived from surface drainage. Consequently the organic matter is much greater than in spring water. The suspended matter in the Thames amounts to about ·02 per cent.

Vegetable impurities are fallen leaves, dead water plants, pieces of land plants, which on decomposition yield carbonic anhydride, CO_2, marsh-gas, CH_4, ammonia, NH_3, and sometimes sulphuretted hydrogen, SH_2.

The animal impurities are the dead bodies of annelidæ, fishes, infusoria, insects, and other animals, which, by decomposition, produce NH_3, CN, HNO_3, PH_3, SH_2, with albumen, mucus, &c., dissolved from their bodies.

And there are, of course, living vegetable and animal impurities.

Surface well water contains generally the surface soakings from cesspools, pigstyes, privies, and sewers, slop, wash, and rain waters. These wells are generally made in the gravelly

soil above clay, and often contain filtered sewage, and not unfrequently are the cause of epidemics.

Deep well or spring water is generally pleasant to drink, and wholesome because the water in passing through great thicknesses of rock becomes oxidised so that harmless products are formed from injurious ones. Injurious animal matter is converted by oxygen into nitrates and nitrites. And these waters contain a larger quantity of alkalies and alkaline earthy salts, and are thus harder than other waters.

The salts generally present in spring water are carbonates, chlorides, sulphates, sulphides, silicates, &c., of calcium Ca, sodium Na, potassium K, magnesium Mg, iron Fe, manganese Mn, &c. There are also present gases such as carbonic anhydride CO_2, nitrogen N, oxygen O, &c., and organic matter which is usually very small in amount.

There is a daily supply of 118 millions of gallons of water to the inhabitants of London :—

	Gallons.
New River	23 millions
East London	22 ,,
Southwark and Vauxhall	18 ,,
Lambeth	13 ,,
Grand Junction	12 ,,
Chelsea	11 ,,
West Middlesex	10 ,,
Kent	9 ,,
	118 ,,

Milkiness is a bad sign. When good water is shaken bubbles should be formed and rise breaking on the surface. It should have no smell unless it may be a slight earthly odour. Water should be kept in clean cisterns. Sometimes when water is kept it acquires a bad odour from the action of decaying organic matter in sulphates, such as gypsum that may be present in it forming sulphuretted hydrogen SH_2. Water having an unpleasant taste should be avoided. When well charged with carbonic anhydride CO_2, it is pleasant to drink, but generally is hard. Good water should be clean and have a pale blue tint; any other colour is generally a sign of impurities. Such water does not contain more than 30 grains of dissolved solids in a gallon. Calcic carbonate forms generally about two-thirds of the solids in solution. The more impurities or residue in water when boiled the harder it will be and will require more soap before a lather is produced. It is a good sign when the residue left on boiling down is white and powdery, but when it is greenish or yellowish it shows that organic matter is present, and when there is an odour like burnt hair produced it demonstrates the presence of organic matter. Good water contains about one grain per gallon of common salt, and if there is much more it shows that the salt is derived from sewage. This water is often rendered unwholesome by

improper storage, by the cistern not being cleansed often enough, by not being covered so as to exclude vermin, and not so tightly as to exclude air. The cisterns having waste pipes connected with a sewer or drains or a pipe with water-closets allow foul air to enter the cistern water and so render it unwholesome. River water is purified to a great extent by settling in large tanks and by passing through filter-beds.

Ordinary hard water dissolves and decomposes soap, forming white curdy compounds with the earths that were previously carbonates or sulphates. The potassium or sodium of the soap unites with the acid part of the lime or magnesia salts, forming sulphates of potassium or sodium which are useless for cleansing purposes, and potassic or sodic carbonate which do cleanse; so that waters that are hard from the presence of carbonates will cleanse with soap, while those that are hard from sulphates, chlorides, or nitrates, will not.

The hardness of water before boiling is termed the total hardness, while that remaining afterwards is termed permanent.

Thames and sea water require about 14 grs. of soap to produce a lather with a pound of water, the Thames water being the harder of the two. The Kent Company's water is harder than either, requiring about 18 grs. of soap to produce a lather with a pound of water.

Water for economic purposes should not con-

tain more than .07 per cent. of soluble matter. Hard water in washing makes linen of a bad colour and clays the skin with curdy matter and does not remove the dirt. A little carbonate of soda may be added to hard water for making tea, but generally far too much is used.

When boiled, the water containing air and gases escapes as vapour, leaving a solid residue consisting of calcic carbonate (chalk), salt, and organic matter.

When water is boiled it generally becomes softer. When boiled, carbonic anhydride ($C\,O_2$) is driven off, being insoluble in hot water, and the earthy matter it held in solution falls to the bottom as a fine powder, taking with it some organic matter.

Earthy matter is deposited in greens boiled in hard water. This is remedied by boiling the water before putting in the greens, and more effectively by putting in a pinch of sodic carbonate and common salt previously.

Distilled water boils at 100° C., and freezes at 0° C., and the boiling point increases with the quantity of solid matter held in solution. Ordinary salt water boils at $100\frac{2}{3}$° C., and when there are $\frac{2}{30}$ of salt it boils at $101\frac{1}{3}$ C., $\frac{3}{30}$ at 102° C., $\frac{12}{30}$ at $107\frac{2}{8}$° C., &c.

Cold water, on being heated, contracts up to 4° C., and expands up to 100° C., when it boils; and warm water contracts on decreasing the temperature to 4° C., after which it expands to

0°, when it solidifies. When kept at rest in narrow tubes, or in vessels from which the air is excluded, it may be cooled to $-15°$ C. without freezing, and in a mixture of almond oil and chloroform it may be cooled to -20, but the slightest agitation is sufficient to cause its immediate solidification. The fixed point 0° C. is taken as the melting point of ice, which is constant, instead of the formation of ice, which is inconstant. Water expands on freezing, 100 volumes of water becoming about 109 volumes of ice.

If we take a certain weight of water at 0° and the same quantity at 80° C., and mix, we obtain twice the quantity at 40° C., but if at a certain weight of water at 80° C. to the same quantity of ice, we obtain twice the quantity of water at 0° C.

If we take two vessels connected at the tops by a glass tube, and put 1 oz. of water at 0° C. in one vessel, and 5.37 oz. in the other, and heat the 1 oz. until it has been entirely converted into vapour, then the 5.37 oz. will boil, thus demonstrating the latent heat of steam to be 537° C. The boiling point of water varies as the pressure; that is, the greater the pressure the higher the boiling point, and the less the pressure the lower the boiling point. Thus on Mont Blanc, where the pressure is .549 of the normal, water boils at 84° C., and at a pressure of two atmospheres, or 15 lbs. above the atmosphere, water boils at 121.8° C., &c.

Water may be heated to about 150° C. without boiling in sealed tubes from which the air is excluded, and when a drop is suspended in oil it may be heated to 170° without boiling. Water may be made to freeze by exhausting the air about it. The water of crystallization of various salts is driven off by heat without altering the properties of the salt, but as the crystalline form depends on this water it is broken up.

It dissolves at 0° C about 1.8 time its volume of CO_2, and about 1,150 times its volume of ammonia, while it only dissolves about .02 and .04 of hydrogen and oxygen respectively, but as the temperature increases the solubility of gases decreases as a general rule. At 20° C it only dissolves 690 volumes of ammonia and about .03 of oxygen.

The solubility of solids increases as a general rule with the temperature.

While water takes up nearly its own weight $M_g\,So_4 + 6H_2o$, it only takes up $\frac{1}{7000}$ part of its weight of $Sr\,So_4$ and $\frac{1}{10000}$ of $Ca\,Co_3$.

The alkaline carbonates are more soluble than any of the other metallic carbonates, water dissolving about $\frac{1}{4}$ of its weight of $Na_2\,Co_3$.

All the ammonia, potassic and sodic salts are soluble in water, and so are the acids containing hydrogen instead of the metal.

Thus water, by its capability of absorbing and dissolving various salts of the elements, furnishes a most admirable vehicle for the supply of all kinds of mineral food for plants.

The presence of organic matter in water destroys the colour of potassic permanganate by adding a little dilute H_2 So_4 to the water, and a dilute solution of the permanganate. When nitric acid is added to the residue of water boiled down to dissolve it, and a little ammonic molybdate, a lemon-yellow colour will be produced on warming for some time if any phosphates are present.

When potassic hydrate, KHo, is added to water containing ammonia, to which a potassic iodide solution of mercuric iodide is added, a brownish or buff colour is produced.

Sodic chloride or common salt in water is detected by adding a little nitric acid and half that quantity of argentic nitrate, when there will be more than a slight whitish blue cloudiness, or a curdy precipitate demonstrating an excess of salt. Lead or copper is detected by adding SH_2 to water, to which a few drops of HCl or CH_3 CoHo acetic acid have been added giving a brown or dark colouration.

We can test the hardness of water by using a soap solution of known strength. The Thames water, supplied to the inhabitants of London, may be softened by slaking one ounce of freshly burnt quicklime in a little water, and afterwards adding sufficient to form a thin cream stirring the mixture in a vessel. Then pour the mixture into 2½ gallons of water in a cistern, adding the rinsing of the vessel. Now

allow about 36 gallons of water to run into the cistern and agitate so that there may be a thorough union of the lime and water, when the lime forms a carbonate with the CO_2 that held the original calcic carbonate in solution, and both carbonates fall in due time to the bottom as a white sediment, together with organic matter.

This is a very cheap process for softening water by which the impurities are reduced to about one third.

One pennyworth of lime will produce the same softening effect as seven shillings worth of sodic carbonate or £5 17s. worth of soap.

CHAPTER XXIII.

FOOD.

THE terms Inorganic and Organic are very comprehensive; the former including all the rocks and minerals that constitute the earth's crust, and the latter all plants and animals. The inorganic rocks and minerals are utterly inert and passive, and have no power inherent in themselves of increase or diminution, which is effected altogether by external agencies or meteorological influences. An inorganic body increases in size by the external addition of a similar kind of matter, and is decreased by disintegrating and other agencies, to which I have already alluded. But organic bodies are endowed with a vital principle that enables them to select certain elementary and compound substances, and from these form new compounds, which are partly eliminated and

partly assimilated, so as to add to their weight or supply the waste caused by the exercise of the vital energies.

Organic bodies are sharply divided into plants and animals. Plants derive their food from the soil or inorganic kingdom, upon which animals cannot exist. All animals are, therefore, obliged to live on plants, or on other animals that live on plants; so that without the previous existence of plants that of animals would be impossible. As stated above, plants require for their growth certain conditions of soil and climate, which farmers would do well to study. Animals also require to be supplied with suitable food and proper treatment. It is found that animals attain higher perfection under some regimens than others. A small proportion of the dry food taken is assimilated by the animal. Pigs will assimilate from 1·5 to 20 per cent. of their food, sheep from 7 to 9, cows from 5 to 7, and others will store up more or less of the food taken by them according as it is more or less concentrated. The remainder of the food goes to supply the waste of the body, to keep up the animal heat, and to form the excreta, &c. In the case of plants the larger part of the food is assimilated, there being little required to maintain plant heat, and little consumed in plant energy, whereas animals expend much in energy and heat. In fattening stock care is taken to minimise animal exercise, so that

as much as possible of the food is stored up in the body, as fat or potential energy, which afterwards becomes kinetic in the bodies of those who consume butcher's meat. A large proportion of the starch, sugar, and fat taken by the draught animals of the farm is consumed in kinetic energy. Plants have the power, with the agency of light (heat), of converting carbonic anhydride, water, and ammonia into protein. The presence of chlorophyl, the green colouring matter of plants, a substance similar to wax, being soluble in alcohol and ether, and insoluble in water, supplies to plants the power of breaking carbonic anhydride, the carbon being retained and the oxygen evolved. Water is also given off from the leaves. In the dark plants become oxidized and carbonic anhydride is evolved. Thus plants manufacture protein or nitrogenous compounds from the mineral kingdom, which animals cannot do, and this protein is essential to animal life. It is consumed by animals together with carbohydrates and oxygen, forming heat and energy, and finally carbonic anhydride, urea, ammonia, and water, which are just the substances required for plant growth. Thus it will be seen that plants prepare food for animals from carbonic anhydride, ammonia, water, &c., and animals from it reproduce plant food. In plants there is a continual formation and evolution of carbonic anhydride.

This oxidation also takes place during the germination of the seeds of plants, their flowering, and the formation of their fruit, carbonic anhydride (CO_2) and heat being given off. This increase of temperature may be observed during the forced germination in malting, when the thermometer rises to about 43° C. The heat evolved in the oxidation of carbon to form CO_2 carbonic anhydride is considerable, as one part by weight of carbon, when oxidized to form CO_2, generates sufficient heat to raise about 8,000 parts of water through one degree Centigrade.

	Raises tons of water 1° C. when oxidized.	Lifts tons 1 foot high when oxidized.
1 lb. lump sugar	1.5	2,200
,, arrowroot	1.75	2,427
,, albumen	2.1	3,100
,, dry flesh	2.2	3,165
,, butter	3.2	4,506
,, beef fat	3.6	5,045

The heat produced is less than here indicated, since the combustion effected within the animal body is not complete, and in the case of nitrogenous matters, as albumen, flesh, &c., a portion of the carbon and hydrogen is carried away to form urea, &c., without any expenditure of energy; for this reason the oxidation of albumen within the body would correspond to about 2,300 tons raised 1 foot high, instead of 3,100, as given, and the potential mechanical work outside the body is only about one-fifth of this, or 475 tons.

Plants obtain carbonic anhydride from the soil by their roots, as well as from the air by their leaves. This CO_2 is obtained from the decomposition of organic matter present in the soil as manures, &c., and ammonia and nitric acid is absorbed by plants from the soil by the decomposition of organic matter or manures. It has not been definitely settled whether plants can take ammonia direct from the air. Plants exercise a considerable amount of selection in the choice of their food ; for instance, they always contain very little alumina, although that compound is generally very abundant in soils, and marine plants contain an excess of potassium, although there is an excess of sodium in the sea-water and very little of the other metal. And we have plants containing an excess of silica, lime, &c., called respectively silica plants, lime plants, &c. In maize, for instance, it has been found by experiment that lime cannot take the place of magnesia, nor magnesia that of lime, and potash cannot substitute soda. The phosphates and sulphates are connected with the formation of protein compounds, and potash and soda with the formation of the carbohydrates, an increase in the assimilation of the alkalies being connected with an increase of starch in plants. Leafless parasites and fungi differ from other plants almost as much as animals do. They live upon the juices of other plants or upon decomposing organic matter.

They do not consume carbonic anhydride, and do not evolve oxygen, as other plants. In plants matter migrates from leaves to roots and from roots to leaves, and eventually to the seed. Thus, for instance, in the case of turnips it has been found that the leaves increase four times more rapidly than the roots from the beginning of July to the beginning of August, from which time to the beginning of September the roots increase twice as rapidly as the leaves, and up to October the leaves decrease, many of them withering and falling off, the whole of the increase going to the roots. When warmth returns again the matter of the roots goes to the leaves, and finally to the flowers and seed; the albuminous matter migrates, leaving the stem and leaves composed principally of cellulose. The increase of plants depends chiefly on the presence of a sufficiency of available mineral food in the soil, on a supply of carbonic anhydride in the air or in the soil, and upon the energy of the solar rays. As the energy of the sun and the supply of CO_2 in the air is inexhaustible, the growth of plants principally depends on a sufficiency of mineral food in the soil. The increase of any one of these three factors increases the growth of the plant, an increase of two still more, and an increase of all three will generally tend to produce any given plant in the highest state of perfection.

For instances observe how the luxuriance and vigour of vegetation augment as the solar energy increases as we approach the tropical from temperate climes. Observe how the yield of certain crops is augmented by the increase of mineral food by the judicious application of manures. Again, observe the highly beneficial effect produced when plants can obtain a sufficiency of carbonic anhydride or ammonia or nitrates by means of their roots. Since animals live upon vegetables there are the same classes of substances found in both; for instance, we have vegetable albumen, fibrine, and caseine, as well as the corresponding animal compounds, and sugar, fat, &c., common to both. In flour and in flesh we have mainly the same constituents. The bones of animals are formed from the mineral matters supplied by vegetables, and when these bones, as we have seen previously, are ground and applied to the land they supply food for plants. Flour or bread and flesh contain the same classes of elements, and nearly all those required for the nutrition of animals. Flesh or blood contains compounds of soda, potash, lime, phosphorus, silica, and iron, together with albumen, fat, fibrine, and gelatine.

The brain contains water, fat, albumen, osmazone, phosphoric acid, and various salts. The lungs contain water, albumen, gelatine, fat, fibrine, caseine, cholesterine, sodic and iron salts, and organic acids.

Bile contains water, fat, sugar, resin, sodic, potassic, and ferric salts, with cholesterine and various organic acids. The liver contains water, fat, albumen, phosphoric acid, and salts of iron, lime, soda, and potash.

Bone and cartilage are composed of fat, gelatine, or chondrine, phosphoric acid, salts of lime, magnesia, potash, soda, and iron, with sulphur. It is necessary, then, that the food taken by animals should supply the constituents contained in the various organs of the body such as the salts of iron, lime, magnesia, soda, potash, and manganese, with sulphuric, hydrochloric, phosphoric, and of fluoric acid, fats and nitrogenous foods to form albumen, fibrine, gelatine, chondrine. Fat is formed rather sparingly from the food taken, and sugar is rapidly and largely formed, with various organic acids, as lactic, acetic, &c.

The following elements are found in the bodies of animals, viz., carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur, chlorine, sodium, potassium, calcium, magnesium, iron, fluorine, silicon, manganese, and copper, together with minute quantities of other elements, such as lead, lithium, &c., and must, therefore, be obtained from vegetable or mineral foods and water, salt, &c. Of these elements iron is a constituent of the blood; it is found in meat, in most vegetable foods, in the yolk of eggs, in milk, &c.

Calcium is found in water as a bicarbonate and a sulphate; in vegetables and in milk, eggs, bones, and in flesh as salts.

Magnesium is usually found in small quantities in those foods that contain lime.

Potassium is a general constituent of plants and animals. It occurs to a considerable extent in the juices that permeate the animal body and in the milk.

Sodium and chlorine are contained to a greater or less extent in all animal foods. These elements are also supplied by common salt, which forms an essential part of animal food.

Sulphur occurs in the vegetable fibrine of corn, in the albumen of turnips, asparagus, cauliflower, &c., and in the vegetable caseine of pease, beans, &c. It also occurs in cruciferous plants, in the albumen of eggs, the fibrine of flesh, and the caseine of milk. Phosphorus occurs as phosphates in plants, and is found in the blood, bones, and flesh of animals.

Fluorine occurs in traces in plants, in milk, blood, &c., and is found in the teeth and bones.

CHAPTER XXIV.

FOOD.

THE proximate constituents of food may be divided into (1) albuminoids, (2) amyloids, (3) fats, (4) mineral constituents, and (5) water.

The albuminoids, proteids, or flesh-formers, consist of carbon, hydrogen, oxygen, and nitrogen, with sulphur and phosphorus. But nitrogen is the most important constituent, so much so that foods have been divided into the nitrogenous and non-nitrogenous. There are several varieties of albuminoid bodies, such as albumen, caseine, and fibrine. There are also other substances containing nitrogen, such as cartilage, gelatine, osseine, &c.

Albumen, the principal constituent of the white of eggs, is the most important of the albuminoids. It is found in the seeds of plants, as a store of nutritive matter distinct from the embryo, when the seed is termed albuminous. It is also stored up in the cotyledons of the seed of plants, as in pease, beans, &c., when it

is termed exalbuminous. It forms the edible part of the cocoanut, the cereals, coffee, poppy, &c., and it is found to a greater or less extent in the sap, seeds, and edible parts of all plants. It also occurs to a greater or less extent in all the serous fluids of animals, in the chyle, blood, flesh, &c. From the albumen of the seed the plant is evolved, and from that of the egg all the parts of the chicken are produced, besides it forms the basis of all animal tissues.

Albumen $C_{72}O_{22}N_{18}H_{112}S$ contains in 100 parts about 53.5 of carbon, 22.4 of oxygen, 15.5 of nitrogen, 7 of hydrogen, and 1.6 of sulphur. It consists of whitish-yellow shining, tasteless scales. When moist it is opaque and white, and when dry it becomes translucent or transparent, yellow, and horny. It is horny in coffee, oily in the poppy, mealy in the cereals, mucilaginous in the mallow, cartilaginous in the cocoanut, and like ivory in the Magdalena palm. Albumen, like the other albuminoids in foods, is dissolved by the gastric juice of the stomach and passes into the blood, forming blood, albumen, blood fibrine, and in the lacteals it is converted into caseine. Fat can be formed from albuminoid bodies during the process of digestion. There are two forms of albumen, one soluble and the other insoluble in water. The solution in cold water is coagulated by boiling; it first turns milky and coagulates about 70° C., be-

coming opaque and insoluble, which is dissolved when nitric acid is added and heated. Strong nitric acid coagulates the solution in water. Millon's reagent imparts to it a bright red or rosy colour. Potassic hydrate dissolves it when heated. When acetic acid is added gradually to a solution it produces a flaky precipitate, which is re-dissolved in excess of the acid. It is soluble in cold water, in which it assumes the appearance of gum, but it is insoluble in boiling water. Soluble albumen is not curdled by the gastric juice like caseine before transformation into peptone, but when insoluble it is not so easily or rapidly digested. The peptones of the stomach are finally transformed by the intestinal secretions into peptones that are more readily absorbed in the system.

Fibrine is present in plants and animals. It is closely allied to albumen and caseine, and these three substances have been termed proteine bodies, because they form the basis of all animal tissues. It is distinguished from albumen and caseine by its separation into the solid state in filaments shortly after the abstraction of any fluid from the body in which it is dissolved. For instance, when some freshly-drawn blood is whipped with the feathered end of a quill fibrine becomes attached in soft white elastic strings. It is a yellow, horny substance when solid. However, the fibrines obtained from different sources are not identical in composition

or properties, and may therefore be a mixture of two or more different substances. Fibrine occurs principally in the blood, chyle, and lymph. There is more in arterial than venous blood, which contains much more than lymph or chyle. As the arterial blood contains more oxygen than venous blood we can understand why there should be more fibrine in arterial blood, since fibrine contains more oxygen than albumen, and in all probability it is formed from it, and not directly from the food. The myosine and syntonine of muscle are varieties of fibrine. When heated in a sealed tube to about 150° C. with water it is dissolved. When a sodic chloride solution is heated it coagulates. It becomes dissolved when boiled for a long time in water. When exposed to the air in a moist state it absorbs oxygen and gives off carbonic anhydride, becoming putrid. The coagulation of fibrine is prevented by the presence of certain potassic and sodic salts. Fibrine, animal or vegetable, is rapidly transformed by the gastric juice, swelling up and becoming an opaline, ropy fluid.

Caseine is white and opaque when moist, but when dry translucent, horny, and crystalline. It is found in beans, pease, and other leguminous seed, and hence it is sometimes termed legumine. It occurs in milk to the extent of about 3 per cent., from which it may be separated in the form of cheese by the addition of a little

rennet, sulphuric, nitric, or hydrochloric acid. It is coagulated also by alcohol, infusion of galls, or creosote. It is not coagulated by heating, as can be proved by warming milk. It is more easily coagulated than the other proteids by acetic and other weak acids. Vegetable is more easily digested than animal caseine. Caseine can be obtained from pease by bruising them to powder and digesting in hot water for two or three hours, and then straining through cloth that allows the water with the caseine in solution to pass through with suspended starch, which falls to the bottom, and on the addition of acetic acid there is a precipitate of caseine. This caseine cannot be distinguished from milk caseine by taste nor tests, so that cheese might be made from it. When heated it carbonizes and emits an offensive odour. Strong nitric acid colours it orange and dissolves it when heated, and strong hydrochloric acid also dissolves it when heated, giving a violet solution. It is insoluble in boiling water, alcohol, and ether, but dissolves moderately in hot alcohol and alkaline solution. Coagulated caseine is easily dissolved by solutions of alkalies and alkaline carbonates. Acetic acid gives a flocculent precipitate with a solution, and in excess redissolves it. When caseine is placed in water it slowly swells, becoming white and opaque. Caseine is curdled by the action of the gastric juice before being converted into a peptone, and

vegetable caseine can be transformed and dissolved by gastric juice with pepsine eliminated.

There are various liquids and muscular tissues of the bodies of animals that contain other albuminoids besides the three above-mentioned, or containing nitrogen, although they may not be classed under the albuminoids.

Of the liquids of the body blood is by far the most important. It contains hæmoglobin, in which there is .42 per cent. of iron, forming the red colouring matter of the blood and assisting in the nutrition and aëration of this fluid. Blood in 1,000 parts contains :—

Water	775. 45
Globuline and cell membrane	131. 11
Albumen	69. 42
Hæmatine	8.375
Extractive matter (urea, kreatine, &c., soluble in water)	3. 27
Chlorine	2.665
Sodium	2.196
Fibrine	2.025
Fat	2.015
Potassium	1.825
Phosphoric anhydride	.663
Oxygen	.535
Calcic phosphate	.213
Magnesic phosphate	.147
Sulphuric anhydride	.091

In the above composition is included small quantities of cholesterine, ammonia, nitrogen, carbonic anhydride, and hydrochloric, lactic,

oleic, phospho-glyceric and stearic acids. The blood has an alkaline reaction and a characteristic odour. In vertebrate animals it is a viscid fluid, of a florid red or purple colour, according as it is arterial or venous blood. It has a specific gravity of 1.058, and when freshly drawn it coagulates in a few minutes, forming a clot and leaving a pale yellow-coloured liquid. The fibrinogen of the liquor sanguinis, the fluid in which the blood corpuscles are suspended, acts on the fibrinoplastin of the corpuscles, and produces coagulated fibrine that entangles the corpuscles in its meshes to form the clot. There are two kinds of corpuscles in the blood, the red and the white. The red corpuscles appear of a yellowish colour when examined by a microscope, circular in one aspect and biconcave in another. They can be seen to form rouleaux, and no nucleus is observable. Hæmoglobine is the colouring matter of the red corpuscles. The white corpuscles can be seen to have a protuberant, irregular outline that is continually changing. They consist of a fluid containing granular matter and a nucleus. The coagulation of the blood is suspended at 0° C., is retarded by low and accelerated by high temperatures not above 50° C., and takes place most rapidly at 40° C. The ordinary temperature of the blood is about 37° C. When the serum is heated it is converted into a nearly solid mass. When the blood is completely burnt there is left

about 8 parts in 1,000 of inorganic constituents, of which sodium, iron, and calcium salts are the most important. When 1,000 parts of the blood are evaporated there is left about 210 parts of a solid residue.

The gastric juice is another fluid of the animal body containing pepsine, another albuminoid, without which digestion would be impossible. The gastric juice is a transparent, colourless fluid, having an acid taste and a peculiar odour. It contains a mixture of hydrochloric, acetic, butyric, and lactic acids, with sodic chloride and lactate, magnesic and calcic chlorides, and ferric and calcic phosphates, but pepsine is an essential constituent. Gastric juice has a specific gravity of 1.02, and in 100 parts there are about—

Water	99.0
Pepsine	.3
Hydrochloric acid, &c.	.1
Sodic and other chlorides	.2
Solid constituents	.4

Boiling does not produce turbidity, but the action of the pepsine is destroyed. Gastric juice may be kept for any length of time at 38° C. without becoming putrid. Warmth accelerates digestion, and cold retards or suspends. Boiling does not coagulate the peptones produced by digestion. Pepsine is insoluble in alcohol, but soluble in water. At a temperature of 37° C. pepsine in an acid solution dissolves coagulated albumen, rendering it incapable of

coagulating by heat, and readily soluble in water. Pepsine possesses high antiseptic powers. It exhibits its powers of digestion only in acid solutions, and any acid is sufficient. A solution of pepsine in hydrochloric acid digests fibrine. Hydrochloric acid alone renders fibrine more bulky and transparent. Pepsine alone has no action on fibrine. When a solution of pepsine in hydrochloric acid is boiled the action of the pepsine is destroyed. Nitric acid does not give a precipitate with peptones. When a solution of pepsine in hydrochloric acid is added to fresh milk a bulky precipitate is produced, which will be digested, and the fluid again becomes milky, containing peptone. The albuminoids are unchanged by mastication, but in the stomach the gastric juice retransforms them into peptones, which are soluble in water and in the body fluids.

Saliva is an animal fluid containing ptyaline, an albuminoid, a very large proportion of water, and very small quantities of salts of sodium, potassium, and calcium, including lactates, calcic phosphate, potassic sulphocyanide, salivary mucus, &c. It is a viscid opalescent fluid, and when examined under the microscope the salivary corpuscles and the flat epithelial mucous cells can be seen. When saliva is boiled its action is destroyed. A temperature of 37° C. is the most favourable for the conversion of starch into sugar, which is its

primary function. When a test-tube containing starch and saliva is placed in a freezing mixture the action of the ptyaline is suspended. Saliva is soluble in water. Acetic acid added to it precipitates mucine, and acids and alkalies destroy its starch-converting power.

Gelatine and the gelatinous tissues of the animal body resemble albumen, fibrine, and caseine in containing carbon, sulphur, hydrogen, oxygen, and nitrogen, but they contain more of the latter element and less of the two first. Another variety has been termed chondrine. Gelatine is obtained by boiling the osseine of bone, the cellular and white fibrous tissues, the skin, the tendons, stag's horns, the feet, the scales and air-bladders of fishes, &c., with water.

Chondrine is similarly obtained from the bone cartilages before ossification and from the permanent cartilages.

Neither gelatine nor chondrine exist as such in the animal body, but are obtained from certain parts mentioned above by the action of boiling water.

Gelatine is a translucent, tough, and almost colourless or brownish-yellow mass, having neither taste nor odour. When heated it blackens and gives off an offensive odour. It is insoluble in ether and alcohol, and swells up in cold water, becoming dissolved when boiled, forming a viscid fluid that on cooling forms a

jelly. Tannic acid gives a buff or yellow precipitate even with very dilute solutions, and an excess of alcohol gives a flocculent precipitate in aqueous solutions. Potassic ferrocyanide added to its solution in acetic acid does not produce turbidity, as is the case with albumen. By frequent boiling with water it loses the power of gelatinizing on cooling. Gelatine is found in the juice of the spleen, but in no other part of the healthy animal.

Chondrine resembles gelatine in its property of gelatinizing, but salts of copper, silver, lead, and acetic acid give a precipitate with the former, but none with the latter. Isinglass can be converted into gelatine by boiling with water. It is supposed to be obtained from the bladder of the sturgeon, but is often obtained from other gelatinous materials. Gelatine and the gelatinous tissues appear to be the only nitrogenous foods that are not converted into peptones by the gastric juice.

Osseine is another albuminoid, containing more nitrogen and less carbon than the proteine bodies. It can be prepared from the bones of animals by acting on them by dilute hydrochloric acid, which dissolves all the earthy matter, leaving an elastic mass that retains the shape of the bone. Osseine also occurs in the connective tissue. It gives elasticity and strength to bones. It is insoluble in dilute acids and cold water, but when boiled in water it is con-

verted into gelatine. This conversion takes place more rapidly when the boiling is effected under the pressure of the steam produced, so that the temperature of the boiling-point is raised.

CHAPTER XXV.

MILK, CHEESE, AND EGGS.

MILK is a white fluid that is opaque, odourless, or having a faint animal odour when fresh and warm, and a sweetish taste. When allowed to stand for some time the cream forms on the surface. The cream is a whitish-yellow, fatty, thick layer. When it is taken off the milk is of a bluish-white tint. When examined under the microscope milk appears clear, with fat-globules suspended in it. The specific gravity of milk is about 1.030. In cow's milk there are in 100 parts—

	Milk.	Skim-milk.	Cream.
Water	86.0	89.0	55.0
Caseine and extractive matters	5.5	4.4	6.0
Sugar	4.3	5.4	2.5
Butter	3.5	0.4	36.2
Salts, various	7.	0.8	.3

Milk does not coagulate when boiled, but caseine, containing fat-corpuscles, forms a film

on the surface. When allowed to stand at the ordinary temperature for some days lactic acid is formed from the milk-sugar by fermentation, and this acid coagulates, the caseine forming curds. When milk is burned the ash contains in 100 parts about—

28.4 of phosphoric acid.
23.5 of potash.
17.3 of lime.
14.0 of potassic chloride.
7.0 of soda.
4.7 of sodic chloride.
2.1 of magnesia.
.5 of ferric oxide.

When milk to which potassic hydrate is added is shaken with ether the fat is dissolved. Acetic acid dissolves the envelope of the fat-corpuscles; and when treated with the dilute acid the investing membrane of the fat-corpuscles becomes visible. When milk is treated with acids the caseine is precipitated; but when the acid is neutralized by sodic carbonate the caseine is re-dissolved; and when dilute hydrochloric acid containing pepsine is added to milk caseine is precipitated. In human milk there is not half the caseine as in cow's milk, and only about one-third of salts; there is also less butter, but more milk-sugar. When milk is skimmed it loses nearly all its fat or butter, and about one-sixth of its caseine, or cheese. On keeping for some time it turns sour, especially in warm

weather, lactic acid being formed, and curds or caseine separating and enclosing a great deal of fat or butter and phosphates. The quality depends to some extent upon the kind of food taken by the animal.

Cheese is formed principally of the caseine of milk, which is separated and consolidated by pressure. It is of a pale or straw-coloured yellow, but it is often artificially coloured orange or a darker yellow by means of a dye termed annatto, which is a red matter derived from the pulp surrounding the seeds of the annatto tree (*Bixa orellana*) by washing, maceration, fermentation, and evaporation. It is made into balls or cakes about 3 lbs. weight, having when broken a light blood-red colour. This dye has an astringent taste, an animal odour, and is often adulterated with injurious substances. It is, therefore, very desirable that cheese-makers should discontinue its use, for it merely gratifies the eye by the colour it imparts to the cheese, without improving the flavour, and actually renders it impure. And red lead when used as a colouring matter is more objectionable still, since it renders cheese poisonous. Carrots, mangold, and saffron are sometimes used to give flavour as well as colour to cheese. The water in it varies from about 33 to 45 per cent.; the caseine and milk-fat are about equal, forming each nearly 30 per cent.; the phosphates form about 3 per cent.,

and milk-sugar and common salt form each about 2 per cent. As an article of food cheese is very nutritious, as it contains about 30 per cent. of caseine, or flesh-forming matter, and about the same amount of fat or butter, which, calculated as of 2½ times the feeding value of sugar or starch, gives about 1 part of flesh-formers to 2½ of heat-givers. But on account of its difficulty of digestion and costive properties, it is not advisable to use it largely as food. It is generally used as a relish in small quantities after an ordinary meal, to give an impetus to the process of digestion. It is advisable to eat cheese with bread or some other food containing a large proportion of heat-giving substances, since it is deficient in these compounds. Of course the facility with which different kinds of cheese is digested varies; the digestibility also varies with the time it has been kept and its degree of consistency or texture. Skim-milk cheese, being more nitrogenous and drier, is not so easily digested as those that are more fatty, crumbly, and moister. When it is kept the caseine and fat suffer decomposition, the former forming ammonia and its sulphide, and the latter butyric, caprylic, caproic, and other acids that impart a flavour and odour to it.

And when cheese is kept a long time a fungus makes its appearance in the form of a blue mould, which, when it is eaten, induces chemical changes among the particles of food,

promoting digestion. The cheese-fly, or hopper, *Piophila casei*, deposits its eggs in cheese, in which they become converted into maggots, commonly called jumpers. Cheese-mites are also found in it ; they can just be discerned with the naked eye, and it is interesting to observe them by the aid of a microscope. These forms of life lower its nutritive value. Cream, whole milk, and skim-milk cheese are the principal kinds. Cream cheese is made from milk to which the cream of the previous milking has been added. The cream curd is put in a cloth and allowed to drain without the assistance of pressure. Stilton is a cream cheese, and also that made at Neufchâtel, York, and Bath. It contains a large proportion of butter or fat.

Cheddar, double Gloucester, Cheshire, &c., are made from the whole milk, and Suffolk, Dutch, Parmesan, &c., are made from skim-milk. Whole milk cheese contains about equal proportions of water, caseine, and milk-fat; while cream cheese[1] has more fat and less water and caseine ; and skim-milk cheese more water and caseine, and less fat.

By the addition of acid or rennet to milk the caseine, constituting about three-fourths of the nitrogenous matter of the milk, is separated, together with most of the fat-globules, some whey, containing milk-sugar, and some of the remaining nitrogenous matter in the form of lacto-proteine,

or albumen. The separation into curds and whey, usually produced by rennet, is the first step. In Holland acid is used. Rennet is prepared from the fourth or digestive stomach of the sucking calf, which only contains the gastric juice, upon which its action depends. The stomach is removed immediately the animal is killed, and the outer skin and superfluous fatty matter are scraped off. The lining membrane is then treated with salt, and the introduction of a little of the brine or a small piece of the dry lining membrane into the milk will curdle a large quantity. The rennet is added after the milk has been heated up to about 29° C.; the curd is formed, and the heat is raised to blood-heat, or 37° C. The curd is formed in about thirty minutes; the whey is pressed out, and it is cut into small pieces by means of a curd-cutter. Some salt is added. The curd is then put in a cloth and placed in a cheese-vat, and subjected to a pressure that consolidates the cheese and squeezes out the whey. During two days it is repeatedly turned in the vat and subjected to pressure until it is sufficiently solid, after which it is placed on a shelf to dry and season till ready for the market. Factories have been established in Canada, the United States, and in this country for the manufacture of cheese. Factory is of better quality than the ordinary cheese in this country, and is sold at a higher price.

Eggs are largely used as an article of food in this country, and we import annually about 400 millions. An egg consists of the white, the yolk, and the shell, forming $\frac{3}{5}$ths, $\frac{3}{10}$ths, and $\frac{1}{10}$th of the weight of the egg respectively. The shell consists of calcic carbonate, calcic phosphate, and organic nitrogenous matter, containing in 100 parts about 91, 6, and 3 of these constituents respectively. There are little pores in the shell through which the young bird obtains its supply of air, which on entering induces decomposition, rendering the egg rotten. If the air is excluded by greasing the shell or any other means the egg will keep fresh for a long time. There is, just inside the shell, a delicate membrane investing the white part which consists of a strong solution of albumen in water, which, when the egg is boiled, coagulates and becomes insoluble in water. In 100 parts of the white there are water, albumen, fat, &c., and mineral matter containing calcic phosphates in the proportion of 84.5, 12.3, 2.0, and 1.2 respectively. The yolk or yellow part also consists of a strong solution of albumen, but it differs from the white in having minute globules of oil suspended in it, forming an emulsion. When heated or boiled the albumen of the yolk coagulates, though to a less extent than the white. The yolk contains, in 100 parts, about 52 water, 30 oil and fat, 15 albumen and caseine, 1.4 of mineral matter, containing phosphates, &c. In

the whole egg, excluding the shell, there are 11 parts of oil and fat to 14 of albumen and caseine, or 28 parts of oil reckoned as starch to 14 of albumen, or there is in the egg 1 part of flesh-formers to 2 of heat-givers. About 2½ or 3 lbs. of eggs would supply sufficient nutriment, containing fat and flesh-formers, for a man during a day; but it is found by experience that the albumen of eggs has a constipative or costive action upon the bowels, so that it is advisable to eat with them bacon or rice, or some other food containing fat or starch, to counteract this action.

CHAPTER XXVI.

FOOD.

IN this country the animal foods that are eaten consist of beef, mutton, bacon, poultry, game, fish, &c. Beef, the flesh of the ox, is the staple article of animal food, so that it is in great demand, and many farmers in order to produce it convert more or less of their tillage land into pasture. By the free importation of corn farmers betake themselves to produce meat; and the latter not paying leads them again to grow corn. In fact, the large importations of both corn and meat into this country prevent the farmers from obtaining for their produce prices affording them a fair profit. Beef contains a great deal of water, upwards of 75 per cent.; that is, about the same quantity as the potato. And when a pound of fresh meat is dried one quarter of a pound is left, the water having been dissipated. Fresh beef contains almost 20 per cent. of myosin, or nitrogenous matter; but when dried it con-

tains more than four times that amount. When the water exudes from the meat, rendering it moist and clammy, it is not wholesome. Beef should have a bright, rich, even colour, and a certain firmness of texture without flabbiness. The water and fat in meat bear an inverse relation—the more fat the less water, and *vice versâ*. In one case there may be 75 per cent. of water, and in the other when much fat is present, only half that amount. The bright colour of the meat is due to the blood permeating it. The oxygen of the air increases its brightness. By washing a piece of lean beef several times in clean water the blood will be washed out and the bright red colour will disappear, leaving the fibrous tissue with a little fat, of which more or less can be dissolved by ether or alcohol. The remainder is myosin, consisting of a fibrous mass. The amount of fat in fresh beef is about 3 per cent.; but when the meat is dried it amounts to about three times as much. As beef usually contains very little fat and no starch, it is advisable to eat with it bread, potatoes, and other foods containing starch. The composition of a piece of beef will not only vary with the joint from which taken, but also with the age of the animal, condition, race, food, and mode of feeding adopted. The meat produced from animals whose growth has been forced is of inferior quality, besides being difficult of digestion and

unpleasant to the palate. There is an excess or over-development of gelatinous and connective tissues and a corresponding deficiency of muscular fibre. Hence the rapid production of beef or mutton is not good for the consumer's digestion, however beneficial it may be to the farmer. The flesh of wild animals consists principally of lean, with a very little fat. The bodies of domesticated animals contain more fat, and especially those that are reared for food, the object being to store up in their bodies as large an amount as possible, so that one-fourth or one-third of the whole dead weight consists of it. It is the presence of this fat that takes the place and performs to a great extent the same functions as starch in bread, rice, potatoes, and other kinds of vegetable foods, that enable some people to live entirely on the flesh of animals, as hunters, in various parts of the world. About two-thirds of the dry increase in the weight of fattening pigs, sheep, and oxen is fat. In cold countries, where the heat of the body has to be kept up, as well as a certain amount of force, in the ordinary daily work of the inhabitants, fat beef, mutton, and bacon are just what is required, the lean that is always present being sufficient to maintain and repair the muscular tissues.

In the British naval service each seaman is allowed from 30 to 36 ounces of dry nutritious food daily, containing 9 oz. of salt meat or half

that quantity of fresh. Patients on full diet in hospitals are allowed 8 oz. of meat daily, and able-bodied men in workhouses are allowed 5 or 6 oz. of meat out of 25 oz. of solid food. Prisoners subjected to hard labour are allowed 16 oz. of meat weekly, included in a daily allowance of 36 oz. of food.

	Albuminoids, &c.	Fat.	Ash.	Water.
Veal	16.5	16.5	4.5	62.5
Beef	15.0	29.8	5.0	50.0
Mutton	12.7	40.0	3.5	43.9
Lamb	10.7	35.0	3.5	50.6
Pork	10.3	50.0	1.5	38.5

In the above table, which gives the approximate percentage composition of various kinds of animal, it will be found that as the quantity of fat increases the amount of water decreases, as well as the ash and albuminoids.

It will be observed that pork contains less nitrogenous matter than any of the above kinds of flesh, but contains more fat, rendering it specially adapted as a food in winter and in cold countries to maintain the heat of the body. Swine's flesh is salted to prevent decomposition, and afterwards dried and smoked. These processes are carried out in factories.

The flesh of the pig is liable to become measly, or infected by the presence of trichinae parasitic animals. If pork containing these

parasites is eaten uncooked, or cooked imperfectly, a disease termed trichiniasis is taken, that often proves fatal. Black-pudding, brawn, sausages, &c., are liable to contain these parasites, and should therefore either be well cooked or not eaten. The flesh of unhealthy or diseased animals is also injurious to the consumer to a greater or less extent. The flesh may contain traces of the medicines given to ailing animals, as well as the poisons of certain diseases. Notwithstanding all the care that may be taken unwholesome meat will get into the market.

The flesh of game and poultry is used as food. The flesh of wild birds, like that of undomesticated animals, contains scarcely any fat. And domestic birds are not fat unless they are fed on food rich in it, when as much fat may be relatively accumulated in their bodies as in those of the cow or sheep. The flesh of the common fowl contains a little more than three-fourths of water, about 14 of albuminoids, and half that amount of ossein, with 2½ per cent. of ash, and a trace of fat. This food is nutritious, as is also that of the hare, rabbit, or other game.

Again, various kinds of fish are largely consumed as food. Their flesh is of a highly nitrogenous or nutritive character, as may be seen by a reference to the table :—

	Nitrogenous Matter.	Fat or Oil.	Ash.	Water.
Herring	10.5 ...	10.1 ...	2.1 ...	76.3
Mackerel ...	13.5 ...	11.5 ...	3.1 ...	71.9
Salmon	13.0 ...	7.3 ...	5.5 ...	74.2
Sole...........	11.2 ...	3.2 ...	1.8 ...	83.8

A certain amount of starchy food should be eaten with fish, in order to supply a due amount of heat-givers with the flesh-formers. There is also a considerable amount of fat or oil in the flesh of many fishes. The more oily a fish is the less digestible it is. Salmon and herrings are not so digestible as sole, whiting, and plaice, that contain little or no fat. Various kinds of fish are preserved for future consumption by the exclusion of air and the removal of moisture. Oysters contain about 13 or 15 per cent. of nitrogenous or nutritive matter. They are generally eaten raw, as cooking renders them more difficult to digest. Mussels are also used as food, when they sometimes prove poisonous. In spring and summer when eaten they sometimes give rise to eruptions that occasionally induce asthma, delirium, paralysis, or death. Ether or an emetic has been proved to be the best remedy in such cases. Oysters have not been known to produce any ill effects. Crabs and lobsters are difficult of digestion; and since they live on very coarse kinds of food, their flesh generally disagrees with even the healthiest of people when eaten by them. Shrimps are also largely eaten; and turtle are imported from the

West Indies and South America for the preparation of soup. Frogs are used as food on the Continent, and other animals are eaten in various countries, such as rats, mice, snails, reptiles, &c., the very names of which are often sufficient to cause a loathing in our minds against the use of these kinds of food. However, doubtless this feeling of repugnance arises from ignorance and prejudice, since all kinds of animal food contain essentially the same constituents, but in different proportions and in conditions that render them relatively easy of digestion, and agreeable or disagreeable to the palate.

All animal or vegetable foods require to be cooked before eating, except perhaps ripe fruits and oysters, and it may be a few others. The ordinary processes of cooking are baking, boiling, frying, and roasting. The boiling of meat should vary according as we prepare soup (or beef-tea) or a joint for dinner. In preparing the soup the meat is put in cold water, which is gradually brought to the boiling point. In this way most of the nutritive matter is abstracted from the meat. In preparing the joint it should be plunged into boiling water for a few minutes, in order to coagulate the albumen on the outside and fill up the pores, so that the water may not extract any further soluble nutritious matter. After this scalding cold water should be added, so as to reduce the tem-

perature from 100 deg. C. to about 77 deg. C., which should not be much exceeded during the remainder of the cooking. As the liquid in which meat is boiled contains valuable mineral and organic matter, it should not be wasted, unless the meat is salt. The larger portion of the valuable constituents of the meat are retained by this method of cooking, the heat from the water passing through the coagulated albumen and heating the water inside it, so that it is steamed or cooked by its own water, with slight loss of nutritive matters. By boiling vegetables the albuminous liquids are coagulated, the starch-grains are broken up and partially dissolved, the sugary and gummy substances go into solution, and volatile oils are expelled, the process rendering them more easily digested. In roasting the joint is exposed to a quick fire, that rapidly coagulates the albumen, forming an outside crust that prevents the escape of the nutritive fluids inside the meat; so that, as in boiling, the meat is cooking by the heat penetrating and forming steam inside that cooks it. In roasting some of the gravy and superficial fat are removed. The roasting of vegetables splits up the starch-granules and renders the constituents more soluble. Roasting renders nearly all kinds of food more easily soluble, digestible, and more nutritive. Baking produces pretty much the same effect on meat as roasting, but by this process an empyreumatic

oil is formed that permeates the meat and renders it not so wholesome.

Meat in boiling loses about one-fourth of its weight, about one-third by baking, and a little more by roasting. This loss in weight is due to a loss of the water of the meat by evaporation, and of fat by its melting by the heat. The gravy formed contains soluble inorganic and organic substances, and a considerable amount of gelatine. In frying heat is applied by the intervention of boiling oil, which, decomposing, forms objectionable compounds.

Warmth, air, and moisture are necessary to effect the decomposition of organic substances. As these conditions are coexistent in most countries a decomposition that renders animal and vegetable foods unfit for the support of life takes place. The absence of heat, or air, or moisture is sufficient to prevent the decomposition of organic substances, and preserves all their properties and nutritive qualities intact. Foods are therefore preserved by cold, by the exclusion of air, or by the exclusion of moisture. To prevent the decomposition of fish they are packed in barrels with ice. Meat and other foods can be preserved in the same way. Elephants have been disentombed out of masses of ice in a perfectly fresh condition in Siberia, having been preserved in this way for ages. In this case there was an absence of the three necessary conditions. However, if the food is only kept cold it does not matter how much

air or moisture is present. Food is put in tins and covered, except a small aperture. The tin and its contents are heated, and the air is driven out and the aperture soldered over, thus excluding the air entirely. In this way food is kept for any length of time, although it may be warm and contain moisture. Food from which moisture has been expelled, although it may be exposed to heat and the atmosphere, will keep fresh. Meat or vegetables are cut up into small pieces and steamed at a high temperature, to coagulate their albumen, and afterwards exposed to a current of dry air, by which all their moisture is abstracted, and the pieces of food become dry, hard, and shrivelled. In this state the food will keep fresh for years, although exposed to atmospheric influences. Salt preserves meat by abstracting moisture; but this method of preservation renders beef less nutritious, and if salt meat is continuously eaten it is injurious. Sugar acts like salt by combining with the water of the substance to be preserved. Sulphurous acid preserves by combining with oxygen, thus neutralising the action of the air. Alcohol preserves by combining with the body and its water. Food suspended in smoke forms a compound with the creosote of the smoke that has a preservative effect. Alum, arsenic, corrosive sublimate, cupric sulphate, and zinc chloride are other substances that form compounds with animal or vegetable substances that retard decomposition.

CHAPTER XXVII.

THE AMYLOIDS, &C.

THE amyloid or cellulose group includes various substances, such as starch, cellulose, dextrine, vegetable mucilage, gum, inuline, &c., all composed of carbon, hydrogen, and oxygen in the same proportion, by weight, viz. $C_6 H_{10} O_5$; grape sugar and fruit sugar, having the same composition, $C_6 H_{12} O_6$, cane sugar $C_{12} H_{22} O_{11}$, and with this group we may include pectine, $C_{32} H_{48} O_{32}$, pectose, metapectic and pectic acids. The gastric juice has no apparent action on the amyloid group of bodies, starchy foods being converted into sugar partly by the saliva in mastication, and this action completed by the pancreatic and intestinal juices. Grape sugar does not require any transformation, but other sugars do to convert them into it before assimilation. These bodies, by splitting up and uniting with oxygen to form carbonic anhydride and

water, give out heat, forming a store of potential energy.

Starch is one of the most important proximate constituents of plants, and by its splitting up yields heat and force. It is abundant in the cereals, tapioca, arrowroot, pease, beans, sago, cassava, potatoes, and generally in the fruits, leaves, and stems of plants. It occurs in the form of granules, that differ in different plants, varying between $\frac{1}{300}$ and $\frac{1}{3000}$ of an inch in diameter. Some granules are circular, some oval, and some angular, but in the same plant the size and shape are very uniform. When seeds are put into the ground their starch is converted into dextrine and grape sugar by the action of a peculiar ferment existing in the seed termed diastase, which would appear to consist of albuminoids in a state of decomposition. Starch is a white tasteless powder, which is prepared from wheat, rice, potatoes, or arrowroot in little columnar masses. It is half as heavy again as water; when heated it blackens, giving the odour of burnt sugar. When boiled with a small quantity of water it forms a paste, and with a large quantity a solution. The aqueous solution when boiled for some time with hydrochloric acid produces grape sugar. When heated to 160° C. it becomes dextrine, and at a higher temperature it is decomposed. When heated with dilute sulphuric acid it is first converted into dextrine and then into grape sugar. It is in-

soluble in cold water, alcohol, and ether. Iodine solution gives a fine blue colour, that disappears on boiling and returns on cooling, and potassic hydrate destroys this colour. The saliva and pancreatic and intestinal juices convert starch into sugar.

Dextrine, as has been stated above, can be prepared by heating starch to 160° C. It has the same composition as starch, but differs from it in several respects. It is soluble in cold water, it does not give a blue colour with iodine, and a solution of tannic acid does not precipitate it. It is a transparent yellow, brittle, tasteless solid, having a vitreous fracture.

Cellulose is another substance having the same composition as starch, but it is unlike starch in several of its properties, being insoluble in cold or boiling water, or in mineral acids, its only perfect solvent being an ammoniacal solution of copper oxide. Unlike starch, it is either indigestible or digested with great difficulty. Herbivorous animals can digest it when newly formed much better than when old, but it is not yet definitely settled whether the human organism can effect any change in it. It forms the great mass of the cell membranes or walls of plants. It occurs in the roots, stems, and fruits of plants that are eaten as food. In linen, cotton, and the pith of certain plants it is found in a state of almost perfect purity. In various plants it differs much in appearance and phy-

sical character. In the turnip and potato it has a spongy consistence; in the shells of plants and vegetable ivory it becomes very hard and compact; in the pith of plants it is elastic and porous; and in the fibres of flax, hemp, &c., it is highly elastic and tenacious. It is a tasteless white substance, heavier than water. Strong sulphuric acid converts it first into dextrine, and finally into grape sugar. Strong hydrochloric acid dissolves it, but on the addition of water it is precipitated. Iodine does not give the blue colour, but does so after a short digestion with strong sulphuric acid, and the colour disappears when either dextrine or sugar have been formed.

Mucilage or bassorine differs from gum in being insoluble in water, forming a jelly with it. It occurs in the root of the marsh mallow, in the bulbs of onions, in quince seed, linseed, &c. Prolonged boiling in water or the action of potassic hydrate converts it into gum. Sulphuric acid containing iodine gives a blue colour with it.

Gum is found in the juices of most plants, especially in some kinds of the acacia, in the plum, apple, &c. Gum arabic, a well-known form, is a yellowish-brown, transparent, tasteless substance. It is a combination of gummic acid, $C_{12} H_{22} O_{11}$, with oxides of calcium, potassium, magnesium, &c. It dissolves in water, and when boiled with dilute sulphuric acid it is converted into dextrine and afterwards sugar.

Neither yeast, iodine, saliva, nor gastric juice affects it.

Inuline has the same composition as starch, to which it is closely allied ; however, it differs from starch in giving a yellowish instead of a blue colour. It is found in the roots of the Jerusalem artichoke, elecampane, dahlia, dandelion, chicory, &c. It is a white, tasteless, and odourless powder. It is slightly soluble in cold but readily soluble in boiling water, from which it is deposited on cooling. When boiled with dilute sulphuric acid it is converted into dextrine, and afterwards into fruit sugar. By prolonged boiling it is converted into gum, and when heated above 100° C. it melts, leaving a gummy mass that is soluble in water.

Sugar consists of carbon, hydrogen, and oxygen, but in different proportions from those elements in starch. There are two principal varieties of sugar, viz. cane and grape sugar, which differ in the proportion of the elementary constituents. Cane sugar has the formula $C_{12}H_{22}O_{11}$, and grape sugar $C_6H_{12}O_6$. Sugar is easily distinguished from starch by its solubility in cold water, by appearance, and by its sweet taste.

Cane sugar is obtained from many plants, the most important being the sugar cane, a grass plant that is extensively cultivated in the West Indies, Brazil, Mauritius, &c., for the supply of cane sugar. The sugar beet is

extensively grown on the Continent, in France, Germany, and Belgium, its root yielding from 9 to 13 per cent. of cane sugar. We also obtain about 2 per cent. of this sugar from the sugar maple, largely grown in Canada and the United States for this purpose. And as sugar is so generally distributed throughout the vegetable kingdom, it can be obtained in quantity from a great many other plants, such as carob beans, Chinese sugar grass, maize stems, the imphee grown by the Zulu Kaffirs, several varieties of palm, &c. Cane sugar consists of oblique four or six-sided rhomboidal prisms. Ordinary loaf sugar is composed of a mass of minute transparent crystals. The crystals of sugar candy are larger than those of loaf sugar because they are formed by a slower evaporation. Its specific gravity does not exceed 1.6, and it is soluble in half its weight of cold water. It fuses at 160° C., on cooling forms barley sugar, and when the heat is continued to 205° C. caramel is formed. When heated it blackens, and when heated with sulphuric acid it blackens quickly. When a solution is boiled with a few drops of hydrochloric acid, grape sugar is formed. When a solution of cane sugar is boiled for a long time fruit sugar is formed, and afterwards grape sugar, so that in the cooking of food cane sugar is frequently converted into grape sugar, and thus the digestive process is assisted to some extent, since cane sugar before assimi-

lation must be converted into grape sugar in the system, if this change has not been effected previously. Under the influence of yeast it is converted into grape sugar, which readily undergoes alcoholic, butyric, or lactic fermentation. Cane sugar is converted by the acids in the stomach, assisted by the presence of nitrogenous matter, into grape sugar, and absorbed by the blood. Fruits are preserved by boiling up with sugar, and the fruit may be preserved whole by putting in syrup of sugar, and when dried the fruit becomes crystallized or candied.

Grape sugar, $C_6 H_{12} O_6$, consists of minute square plates, forming hard, warty-looking masses. It crystallizes with difficulty, and is two and a half times less sweet than cane sugar. It occurs in three forms—those of dextrose, lævulose, and maltose. Dextrose, or grape sugar proper, is found largely in all sweet fruits, and in honey there is about 80 per cent., with lævulose. It has derived its name from the grape, containing about 13 per cent., from which it crystallizes out in hard, warty-looking masses on drying the ripe grapes. Turkey figs dried contain about 56 per cent. of grape sugar. Lævulose found in acid fruits and honey dries up into resinous masses, being uncrystallizable. Maltose—about 5 per cent.—is found in the artificially-sprouted grain termed malt. When treated with strong sulphuric acid it does not blacken so readily as cane

sugar. At 100° C. it fuses, losing water; sulphuric acid does not decompose it like cane sugar, but forms with it sulpho-saccharic acid. Grape sugar may be made from cane sugar, dextrine, and starch by the action of weak acids and by the action of strong sulphuric acid upon cellulose and cotton, paper, linen, and woods, &c., containing cellulose. It forms a valuable food, especially for young animals, since it is immediately absorbed into the circulation without any transformation or digestive process. However, in the stomach it gives rise to the production of lactic acid, that causes in excess a derangement of that organ. By the fermentation of a solution of sugar under the influence of caseine, butyric acid is formed. This variety of sugar is probably, under special circumstances, converted into fat, thus :— $20\,C_6H_{12}O_6 = 2\,C_{57}H_{110}O_6$ (stearine) $+ 6\,CO_2 + 10\,H_2O + 43\,O_2$. Bees can convert sugar into wax.

Milk sugar, $C_{12}H_{22}O_{11}$, has the same composition as cane sugar. It consists of four-sided milk-white prismatic crystals, containing one proportion of water, so that they feel gritty and crunch when pressed by the teeth. When taken as food it is converted into grape sugar before assimilation. It is not fermentable, but when boiled in dilute acids it is converted into fermentable sugar. In cows' milk there is between 4 and 5 per cent. of lactose or milk sugar.

There is also a variety of sugar termed *inosite*, found in the bodies of animals, sweet substances, glycyrrhiza occurring in liquorice, mannite in manna, &c.

Pectose is a gelatinous pulpy matter that occurs in fruits, especially when unripe, as in the pear, peach, apple, gooseberries, strawberries, raspberries, currants, &c.; in roots, as the beet, carrots, parsnips, turnips, melons, marrows, cabbages, &c. It forms a jelly when boiled with water, and when dried it resembles isinglass or gum. By the action of dilute acids, pectose is converted into pectine, $C_{32}H_{40}O_{28} + 4\ H_2O$, which is soluble in water, pectose being insoluble. In the ripening of fruits, pectose is converted into pectine; and when fruits or those preserved are eaten, the pectose is changed into the soluble pectine, that is capable of absorption and assimilation in the animal body. It is the pectose of fruits that forms the jelly, and gives firmness and consistency to jams. Cherries, grapes, gooseberries, peaches, apples, and pears contain respectively, $\frac{2}{3}$, $\frac{31}{33}$, $\frac{32}{33}$, 1, $1\frac{1}{7}$, and $1\frac{1}{3}$ per cent. of pectose, but each of these contains about double this amount of soluble pectine, except in the case of the peach, which contains about seven times as much, the grape half as much, and the cherry about the same quantity. Pectine may be obtained from the juice of ripe fruits by adding oxalic acid, which throws down the lime and

tannin to coagulate the albumen, and, on adding alcohol to the liquid separated from these precipitates, pectine is precipitated in the form of glutinous strings. A weak solution of sodic carbonate converts pectine into pectic acid, $C_{16}H_{22}O_{15}$, a gelatinous substance. Pectic, pectosic, and metapectic acids are formed from pectine by fermentation at a definite temperature.

CHAPTER XXVIII.

FOOD.

THE fats and oils occur to a greater or less extent in all plants and animals. The fats and oils are essentially the same class of substances, being fats when of a solid consistency and oils when fluid. They contain carbon, hydrogen, and oxygen like the amyloid or starchy substances, the ratio between the carbon and hydrogen being roughly as 1 to 2 in each, but the ratio of hydrogen to oxygen in starch and sugar is as 2 to 1, whereas in the fats the ratio is about 18 to 1, so that the oils and fats contain proportionately about eight or nine times less oxygen than the amyloid, or starchy, or sugary foods. Thus fatty foods, such as stearine, palmitine, or oleine, in becoming carbo-hydrates unite chemically with 49, 41, or 46 atoms of oxygen producing heat; hence the superiority of fat as a heat-giver to starch or sugar. The hydrogen in starch and sugar being fully oxidized, these substances can only produce heat

in the animal body by the oxidation of the carbon, whereas fats or oils can produce heat by the increased oxidation of the hydrogen as well as the oxidation of the carbon. Fat or oil is generally considered to have about two and a half times the feeding value of starch or sugar.

The most abundant fat in beef and mutton consists of stearine; palmitine also occurs, but in less quantity.

Stearine, $C_{57} H_{110} O_6$, is a crystalline white fat. It fuses in water heated to 71° C. When boiled with potassic hydrate an emulsion is produced, and it gradually dissolves forming a soap. It does not dissolve in boiling water, but dissolves in boiling alcohol, from which it is deposited on cooling.

Palmitine, $C_{51} H_{98} O_6$, is a white, scaly, crystalline fat. It is the principal constituent of palm oil, and occurs largely in butter, goose, and human fat. It forms a wax-like mass on cooling after fusion at a temperature of about 63° C. It dissolves readily in boiling alcohol, but not in water.

Oleine, $C_{57} H_{104} O_6$, is a yellowish or colourless, inodourless oil, and forms the fluid part of animal and vegetable fats. Oleine, together with stearine and palmitine, forms the great bulk of animal and vegetable fats. It remains fluid at a low temperature, and forms acicular crystals at 3° C. It dissolves readily in ether, but is insoluble in water. When exposed to the

air it becomes darker, rancid, acid, and assumes a resinous appearance.

The fats or fixed oils are of animal or vegetable origin, some being solid like suet, some solid and soft like butter, and some fluid as in the case of oils. In animals fat is found in the omentum, under the skin, and round the kidneys.

The fat of warm-blooded animals is generally solid, while that of cold-blooded animals and fish is liquid. The principal solid fats are butter, grease, lard and suet, and the fluid animal fats are cod-liver, neat's foot, sperm, and whale oils. A vegetable fat is found in the tissues of plants and their seeds and fruits. Linseed contains 20 per cent. and rapeseed twice that amount of fat. In animal and vegetable fats, a certain quantity of an albuminoid occurs that exerts an important chemical action on the fat when kept for any length of time. The fat is generally extracted by pressure from plants, and, when it is solid at the ordinary temperature, it may be obtained by boiling the portion of the plant containing it with water, and allowing to cool, when it will form a solid layer on the top of the water. All fats and oils are lighter than water, the specific gravity varying between .91 and .94. When pure and in the fresh state they are without odour or taste, but on exposure to the air they become oxidized and acid, acquiring rancidity,

a disagreeable odour and a deeper colour. Suet is the fat from the omentum and kidneys of the ox and sheep. It consists of a mixture of animal fats, stearine predominating, forming about three-fourths of the whole. It is white, soft, and forms tallow when melted, and fuses about 40°C. Lard is the melted fat of the pig. It contains stearine, oleine, and margarine, the oleine predominating. When pressed at a low temperature the oleine and stearine are separated. The best lard is obtained from the fat surrounding the kidneys, and, when pure, is without taste or smell, and is white and firm. Linseed oil is obtained from *Linum usitatissimum* by pressure, or the application of heat. The seeds yield from 18 to 27 per cent. of the oil. When cold pressed and pure it is a pale yellow, having a pleasant taste, but the article of commerce is usually amber-coloured, and its odour and taste are rather disagreeable. It also contains margarine chiefly, and palmitine and stearine.

Butter consists of about 87 per cent. of the fat of milk, 10 of water, 1 of caseine, 1 of common salt, and $\frac{1}{3}$ per cent. of sugar of milk.

The milk fat in butter consists of a mixture of oleine, much palmitine, stearine, and several other fats—as caproine, capryline, and butyrine. When heated in a glass tube it melts, the water remains at the bottom, the curd on its surface with a little of the melted fat, and the top layer

consists of a fluid like oil. Butter dissolves in alcohol. When the fats in butter are saponified they each yield glycerine and butic, caprylic, caproic, and myristic acids. About 15° C. is the best temperature for churning milk for butter, and 1 lb. should be obtained from twelve quarts of milk. If butter is good and pure, a portion melted in a glass tube plunged in hot water should not show more than about $\frac{1}{7}$th or $\frac{1}{8}$th of volume of water at the bottom of the tube, the remainder of bulk consisting of a little curd, with the butter fat melted at the top.

Bile, in 100 parts, contains 90.44 of water, 8 of biliary and fatty substances, including resinoid acids, .85 of water extract, chlorides, phosphates, and lactates, .41 of soda and .3 of mucus, including sulphur. Human bile is a dark-yellow-coloured fluid, having a bitter taste and a nauseous fragrant odour. It is essentially a soap formed by the union of soda with taurocholic and glycocholic acids. This soda is obtained from the salt Na Cl taken as food, the chlorine furnishing hydrochloric acid to the gastric juice. It has, when fresh, a very slight alkaline reaction. It sinks in water, and when shaken therein it assumes the appearance of soap-suds. When acetic acid is added to bile, mucine is thrown down as a curdy precipitate. A purple colour is given when a little cane sugar solution is added to diluted bile, to which strong sulphuric acid is added. Nitric acid

changes the colour from yellow to green, blue, indigo, violet, red, and orange, back to yellow.

Glycogen is an opalescent, tasteless, amyloid substance in solution. It occurs in the cells of the liver, and when boiled with dilute sulphuric acid yields grape sugar. When Fehling's fluid is added to glycogen, to which saliva has been added and boiled, there is a yellow precipitate showing the presence of sugar. Any animal ferment, as saliva or pancreatic juice, readily converts it into sugar.

A dilute iodine solution produces a brownish-red colouration, disappearing on warming, re-appearing on cooling, and when saliva is added the appearance of the fluid changes, and iodine does not give the brownish-red colouration.

The pancreatic juice is a clear, colourless liquid, and odourless, having an alkaline reaction. It contains about .68 of mineral substances, about 1.2 of organic matter, and about 2 per cent. of solid constituents, containing a ferment termed pancreatine and soda. This fluid serves to dilute the chyme, to convert any starchy matter therein into sugar, and to effect the chemical union of chlorine with its sodium to form chloride of sodium or common salt. It also has a digestive action upon the fats in the chyme, emulsifying them and rendering them more readily absorbable.

CHAPTER XXIX.

FOOD.

TABLE showing the approximate percentage composition of nourishing constituents (albuminoids, carbohydrates, and fats), together with ash and water in various kinds of food, arranged in the order of albuminoids.

Food.	Ash.	Water.	Albuminoids.	Carbohydrates.	Fats.
American flesh meal.	3.6	11.6	72.8	—	10.1
Glutine (dry)	1.6	11.6	68.9	16.1	1.5
Pumpkin seed cake..	8.0	12.0	55.5	7.2	10.3
Cockchafer (dry).....	6.6	13.6	55.5	—	9.0
Candle-nut cake......	9.0	7.0	54.6	14.2	8.2
Earth-nut without shells	12.5	7.5	47.5	15.5	6.3
Beech mast without shells	7.6	12.6	37.0	28.0	6.8
Lupines, yellow......	4.0	13.0	35.3	27.3	4.3
Walnut cake	5.0	13.5	34.5	25.0	11.0
Sesamma cake.........	11.6	11.6	34.5	16.3	10.3
Cottonseed cake (decorticated)	7.7	10.0	34.3	17.0	10.0
Sunflower cake	10.6	10.0	34.2	17.0	11.0
Linseed meal pressed	7.3	9.7	34.2	29·3	3.9
Rape meal ,,	8.0	7.7	32.3	26.7	2.0

Food.	Ash.	Water.	Albuminoids.	Carbohydrates.	Fats.
Earth-nut cake	7.1	9.7	32.0	14.4	8.4
Poppy seed cake......	8.5	10.0	32.0	23.2	7.2
Madia cake............	6.7	11.1	31.5	6.9	12.9
Rape Cake	7.5	15.0	30.3	18.7	7.7
Linseed cake	7.7	11.7	28.3	29.0	9.0
Earth-nut...............	3.2	6.2	28.2	5.9	39.0
Lupines (blue)	3.2	14.0	28.0	34.4	4.4
Vetches	2.7	14.0	27.5	44.0	2.4
Hempseed cake	6.0	10.6	27.0	20.5	5.0
Beans	3.0	14.5	25.5	44.0	1.4
Cottonseed cake (undecorticated)	6.3	11.3	24.5	14.0	5.5
Ground or pea nuts..	1.7	7.5	24.5	11.9	30.0
Beech mast cake......	5.2	10.5	24.0	16.5	5.0
Conger eel	1.8	82.0	24.0	—	5.0
Lentils..................	3.0	14.3	24.0	46.5	2.2
Cocoanut cake	5.0	12.6	23.3	30.2	8.2
Malt dust...............	6.8	8.0	23.0	38.0	1.8
Lupines when flowering	4.0	16.6	23.0	36.0	0.6
Haricot beans.........	3.0	14.0	23.0	52.2	2.3
Cottonseed	7.7	7.7	22.8	11.7	27.3
Pease	2.4	14.4	22.4	50.0	1.6
Pike.....................	1.2	79.0	21.0	—	0.6
Madia seed	4.6	8.6	20.6	3.7	37.0
Linseed	3.4	12.4	20.5	15.2	35.2
Bran from wheat groats	4.2	11.2	19.8	41.4	4.0
Vetches before flowering...................	9.2	16.6	19.8	31.0	1.4
Rapeseed...............	3.8	11.8	19.4	9.3	40.3
Sesame seed...........	8.6	4.6	18.8	15.4	35.4
Cockchafer fresh	2.3	70.3	18.8	—	3.0
Palm-nut meal pressed	3.9	9.0	18.5	33.3	2 3

Food.	Ash.	Water.	Albuminoids.	Carbohydrates.	Fats.
Tree leaves	4.0	11.4	18.0	36.0	5.0
Poppy seed	5.5	14.5	17.5	12.3	39.0
Buckwheat bran	3.4	14.0	17.0	38.0	3.8
Bokhara clover hay	8.0	14.0	16.6	31.6	1.6
Palm-nut cake	3.6	9.0	16.3	33.3	13.0
Hemp-seed	4.4	12.3	16.3	15.0	30.0
Lucerne good (hay)	6.7	16.7	16.0	31.0	0.9
Malt dust cake (maize)	7.2	10.2	15.4	41.0	10.0
Red clover, prime	7.0	16.4	15.3	37.5	2.0
Milk preserved	2.5	21.5	15.0	45.0	11.5
Alsike clover	6.0	16.0	15.0	34.8	1.8
Millet grain	1.6	13.0	15.0	61.5	5.0
Buckwheat	2.3	13.3	15.0	44.1	1.2
Barley bran	4.0	12.0	14.8	37.3	3.6
Yellow clover trefoil hay	6.0	16.6	14.6	36.2	2.0
White clover middling	6.0	16.6	14.5	35.8	2.0
Lucerne, middling	6.1	16.1	14.3	28.1	1.0
Pease in flower	2.0	16.7	14.3	31.0	1.6
Lentil straw	6.5	16.0	14.0	31.0	1.2
Vetches in flower	8.4	16.4	14.0	32.5	1.5
Wheat bran	5.3	13.3	14.0	37.5	3.5
Red clover, good	7.6	16.0	13.5	38.1	1.7
Meadow hay, very good	6.0	16.6	13.5	43.1	1.2
Sainfoin in flower	6.3	16.3	13.3	36.0	1.6
Wheat seed	1.7	15.0	13.0	63.1	1.2
Sunflower seed	3.0	8.0	13.0	17.7	21.0
Walnuts	1.7	44.7	12.6	9.0	31.5
Vetch and oat hay	7.2	16.6	12.6	35.7	1.1
Crimson clover hay	5.0	16.5	12.2	34.8	1.4
Oats (seed)	2.7	14.3	12.0	41.8	4.8
Lupines after flowering	6.2	15.2	11.8	39.0	0.9

Food.	Ash.	Water.	Albuminoids.	Carbo-hydrates.	Fats.
Meadow hay, good...	7.0	15.0	11.6	42.0	1.0
Barley meal............	5.6	11.2	11.6	24.3	3.4
Rice meal........... ..	9.6	10.6	11.5	39.5	8.5
Italian rye grass......	7.8	14.2	11.2	41.4	1.4
French rye grass......	10.0	14.0	11.0	33.0	0.8
Rye seed...............	1.8	14.2	11.0	64.0	1.6
Rye flour...............	1.6	13.0	10.5	71.0	1.5
Beans, pods............	5.5	15.0	10.5	34.6	1.2
Green rye hay when flowering............	5.2	14.2	10.4	44.3	1.3
Perennial rye grass when flowering....	6.4	14.4	10.2	35.2	0.8
Beans, straw...........	4.5	16.0	10.2	35.2	0.5
Pulse straw, very good..................	5.0	16.0	10.2	34.6	0.6
Maize seed	1.5	14.5	10.0	57.8	4.8
Barley seed............	2.2	14.2	10.0	57.7	1.7
Spelt seed	3.7	14.7	10.0	39.1	1.1
Meadow hay (middling)	6.2	14.2	9.7	41.0	0.9
Timothy grass (flowering)	4.4	14.4	9.7	43.4	1.4
Seed clover straw ...	5.5	16.0	9.4	28.5	1.0
Irish moss	—	—	9.4	57.5	—
Dry malt without sprouts...............	2.3	7.3	9.3	62.6	1.6
Buckwheat seed......	1.7	14.0	9.0	44.1	1.2
Iceland moss	5.0	50.0	8.7	73.5	—
Vetch pods............	8.0	15.0	8.5	34.2	1.2
Filbert kernels	—	—	8.3	13.6	28.6
Pease pods	6.0	15 0	8.0	36.2	1.2
Maize bran	2.3	12.0	8.0	50.0	3.5
Rice corn (naked) ...	0.3	14.0	7.6	71.3	0.3
Meadow hay (poor)	5.0	14.0	7.6	34.5	0.5
Vetch straw............	4 5	16.0	7.5	31.5	0.5

Food.	Ash.	Water.	Albuminoids.	Carbohydrates.	Fats.
Carob beans	—	—	7.0	74.1	1.1
Pease straw............	4.5	16.0	6.5	33.5	0.5
Horse Chestnuts......	1.4	49.4	6.4	35.0	1.0
Fresh malts with sprouts............	1.6	47.6	6.4	34.6	1.0
Dates	1.7	20.7	6.4	73.0	0.2
Wheat refuse from starch manufactory	—	—	6.2	14.7	1.2
Common pearl barley	—	—	6.2	77.0	1.3
Rye refuse from starch manufactory	0.8	70.0	6.0	17.0	1.2
Cream	0.6	62.0	6.0	2.5	36.5
Lupine straw	4.0	16.0	6.0	41.3	0.3
Figs......................	2.4	17.4	6.0	73.0	0.9
Cocoanut...............	—	—	—	5.5	11.36
Mushrooms............	0.5	90.0	5.0	3.7	0.7
Brewers' grains	1.2	76.4	5.0	9.4	0.4
Shelled acorns	1.5	17.0	5.0	60.9	2.9
Wheat chaff...........	9.2	14.2	4.5	32.4	0.4
Broom....................	4.0	51.4	4.5	17.0	0.8
Lucerne	2.0	74.0	4.5	7.3	0.3
Rich pasture grass...	2.2	78.2	4.4	10.4	0.4
Lupine pods	3.5	14.5	4.4	44.0	0.5
Glutine refuse from starch manufactory	0.4	70.0	4.4	24.5	0.5
Skim milk	0.9	90.0	4.2	5.4	0.4
Oat chaff..............	10.0	14.2	4.0	36.6	0.6
Spring barley straw	4.2	14.2	4.0	36.4	0.4
Rape husk	8.4	14.0	4.0	33.7	0.7
Cow milk	0.7	87.0	4.0	5.0	3.5
Heath	3.7	54.7	3.7	15.5	1.0
Millet	2.0	70.0	3.7	14.3	0.3
Rye husk...............	7.6	14.4	3.6	34.8	0.4
Italian rye grass......	2.7	73.2	3.6	12.4	0.4

Food.	Ash.	Water.	Albuminoids.	Carbo-hydrates.	Fats.
Perennial rye grass...	2.0	70.0	3.6	12.3	0.3
Oat straw	4.0	14.0	3.5	37.6	0.6
Rape straw	4.0	16.0	3.5	35.0	0.5
White clover (in flower)	2.0	80.5	3.5	8.0	0.5
Vetches (in flower)...	1.8	82.0	3.5	6.6	0.3
Pasture grass	2.0	80.0	3.5	10.0	0.4
Timothy grass.........	2.2	70.0	3.4	15.0	0.5
Green rye	1.6	76.0	3.3	11.0	0.4
Green Jerusalem artichoke	2.8	80.0	3.2	15.3	0.3
Carrot leaves	3.5	80.2	3.2	7.0	0.5
Sainfoin (in flower)...	1.5	80.0	3.2	8.0	0.3
Winter barley straw.	5.4	14.4	3.2	31.4	0.4
Red clover	1.7	78.0	3.2	9.5	0.5
Pease (fodder).........	1.5	81.5	3.0	7.3	0.3
Butter milk............	0.5	90.0	3.0	5.5	1.0
Barley husk............	10.0	14.2	3.0	35.0	0.6
Maize straw............	4.1	15.1	3.0	37.0	0.3
Lupine fodder (green)	1.2	85.2	3.0	7.0	0.1
Winter wheat straw.	4.5	14.5	3.0	32.0	0.4
Grass (before flowering)	2.0	75.0	3.0	13.0	0.4
Bokhara clover	2.0	87.5	3.0	4.0	0.2
Field beans (fodder).	1.0	87.2	2.8	5.2	0.2
Rape	1.6	86.0	2.7	7.4	0.4
Kohl rabi leaves......	1.8	85.0	2.7	7.4	0.4
Winter rye straw	4.2	14.2	2.5	32.4	0.4
Mixed oats and vetches	1.4	84.0	2.4	7.0	0.2
Buckwheat	1.5	85.0	2.4	6.4	0.4
Seakale	0.6	93.0	2.4	3.6	—
Green oats	1.4	81.0	2.3	9.0	0.2
Yam	1.5	79.5	2.2	17.2	0.5
Potatoes	0.9	75.0	2.2	26.3	0.3

Food.	Ash.	Water.	Albuminoids.	Carbohydrates.	Fats.
Cabbage and turnip leaves	2.3	88.3	2.1	5.0	0.3
Jerusalem Artichoke.	1.9	80.0	2.1	15.3	0.3
Acorns unshelled	1.0	56.0	2.0	27.6	1.6
Molasses	1.6	92.0	2.0	4.5	—
Mangel leaves	1.8	90.8	1.9	4.0	0.2
Sugar beet pulp pressed	3.4	70.0	1.8	18.2	0.2
Human milk	0.2	89.2	1.6	7.0	2.2
Parsnip	0.7	88.2	1.5	10.2	0.2
White cabbage	1.2	89.0	1.5	8.0	0.5
Maize cobs	2.7	14.0	1.4	41.4	0.4
Carrot root	0.9	85.0	1.4	11.0	0.2
Tomatoes	0.8	89.8	1.4	7.3	—
Turnip cabbage	1.0	87.0	7.3	9.4	0.1
Green maize	1.1	82.1	1.2	10.0	0
Celery	0.8	93.2	1.2	4.7	—
Mangold wurzel roots	0.8	88.0	1.1	9.1	0.1
Turnip root	0.7	92.0	1.1	5.1	0.1
Cabbage stalks	2.0	82.0	1.0	11.2	0.2
Sugar beet-root	0.7	81.5	1.0	15.1	0.1
Butter	0.9	10.0	1.0	0.3	87.0
Rhubarb	0.5	95.0	0.9	3.2	—
Potato fibre from starch manufactory	0.4	84.0	0.8	11.3	0.1
Whey	0.6	93.0	0.8	5.0	0.3
Lettuce	1.0	96.0	0.7	4.7	—
Grapes	—	—	0.7	18.0	—
Pumpkin	1.0	89.1	0.6	5.7	0.1
Vegetable marrow	0.5	94.5	0.6	4.0	0.2
Peaches	0.6	85.0	0.5	24.0	—
Pears and apples	0.4	83.0	0.4	15.2	—
Gooseberries	0.5	86.0	0.4	11.6	—
Cucumbers	0.4	96.0	0.2	3.2	—

In the above table there is given for a great variety of food the albuminoids, such as albumen, fibrine, caseine, and all substances containing nitrogen in their relative albuminoid value; but the feeding value expressed in albumen never exceeds, but in many cases is considerably less than the percentage given. The percentage of carbohydrates, such as starch, sugar, &c., are also given with the amount of fat, so that a rough estimate may be formed of the value of any food by a comparison of the percentage amount of albuminoids with the combined percentage of carbohydrates and fats multiplied by 2½. Thus in the case of wheat there is 63.1 of carbohydrates, to which add 2½ times 1.2 the amount of fat, and we have $63.1 + 3 = 66.1$ which, divided by 13, the amount of albuminoids, gives 5.1, the proportion of carbohydrates to albuminoids, taken as unity; or, expressed roughly, the quantity of carbohydrates is more than five times the amount of albuminoids. In this table it will be observed that water forms a very large part of roots, fresh fodder, &c. In the dry foods, such as hay, it forms 15 to 17 per cent., and in the cereal grains about 14 per cent. Stores contain upwards of 60 per cent. of their live weight of water, so that it may be viewed as a permanent and essential part of the animal constitution. It serves to carry nutrient matters to their destination in the animal body, and to

eliminate from it all waste materials. In the case of dried foods, such as hay, the defective water should be supplied separately.

The amyloid or starchy foods serve to keep up the heat of the body by the oxidation of their carbon to form carbonic anhydride; and in those animals living on flesh alone, the fat, by the partial oxidation of the contained hydrogen, and the oxidation of the carbon, serves the same purpose as starch. It will be observed that as a general rule there is present in most plants a large amount of starchy and saccharine matter. But the amyloids, although the principal, are not the only sources of heat, for the albuminoids and other foods containing carbon are combustible or capable of uniting with oxygen. In a coal fire the oxygen unites rapidly with the carbon of the coal producing heat, whereas in the body there is a slow combustion, since the oxygen inspired, and circulating in the blood, only unites in very small quantities with very small particles of the carbonaceous food all over the body, so that a comparatively small amount of heat, continually evolved in the blood all over the body, suffices to keep up the temperature as well as forming a reservoir of heat, in order to enable animals to do work or overcome any obstacles that may present themselves. Of course when work is done by animals there is a quicker respiration of air as well as a quicker circulation of the blood, so

that a much larger quantity of heat is evolved than is normally the case. The oxygen is carried by the blood to all parts of the animal system in loose combination with hæmoglobin or the red colouring matter of the red corpuscles. But to what extent this oxygen unites with the combustible constituents of the blood, the muscles, or juices of the flesh respectively, has not been definitely settled for the purpose of producing heat and mechanical force. In a table given above, the amount of heat produced by the combination of various kinds of food is given. This oxidation takes place in plants as well as animals, but to a much less extent. In many animals it is essential that the temperature of the body should be maintained at about 37° C., that is, considerably above 16° C. the ordinary temperature of the air. This excess of temperature 21° C. must be maintained by the combustion or oxidation of the food taken as well as sufficient to do mechanical work outside the body of which only one-fifth of the generated internal heat produced is available. Hence the necessity for the rapid and complete oxidation of the blood containing the elaborated constituents derived from food. In man the whole of the blood is oxidised every thirty seconds, in the lungs containing about 600 millions of cells having a surface of 1,440 square feet for the purposes of bringing the oxygen of the air in contact with the blood through the thin cell

walls. In plants the existence of a temperatur to any extent higher than the air is unessential, and very little heat is expended by plants in mechanical work. Nevertheless, oxidation and the production of heat does take place to some slight extent in the flowering parts of plants which are generally one or two degrees higher in temperature than the surrounding atmosphere. In the case of the flower of the *Arum cordifolium*, the temperature has been about 50° C. while the surrounding air was only about 19° C. In this case the oxygen of the air produces heat by uniting with the starchy ingredients of the sap of the flower stalk.

From the table it will be seen that the albuminoids form a considerable proportion of all foods. In the grain of the cereals these compounds form about 10 per cent., and in the seeds of leguminous plants, as pease and beans, they form upwards of 20 per cent. And it would appear from feeding experiments that the ratio of nitrogenous to non-nitrogenous constituents should in the food given to stock equal as nearly as possible that proportion existing in the cereal grains, such as wheat, in which the nutrient albuminoids are to the non-nitrogenous carbohydrates and fats as 1 : 5. In human diet, nitrogenous foods are considered of superior value to starchy or fatty foods, but in the fattening of stock which is now carried on so

extensively to supply the meat market, the fats, oil, and non-nitrogenous constituents are of more value. The art of fattening cattle consists in the accumulation of an excess of fat in their bodies. It is a general opinion that the fats and oils when taken as food by stock form fat, provided there is sufficient starch and sugar supplied in the food to maintain the animal heat and force, otherwise the fats will be used in giving heat instead of forming fat in the body. And when there is not sufficient fat given in the food, then it is formed by the breaking-up and rearrangement of the albuminoids. The albuminoids, although they may under emergencies form fat and give heat to the body, are essentially flesh-forming materials. And starch, sugar, &c., although heat and force producers essentially, may under emergencies form fat in the animal body. And fats and oils, although their function is to supply fat to the body, yet when necessity requires it they may be broken up and oxidised to evolve heat and yield force. In fattening stock, these nutrient constituents of food should be supplied, as far as possibly can be done, in proper proportions, so that each constituent of food should perform that special function for which it is adapted, and not be required to perform other offices for which it is not designed. If a proper study were made of the process of fattening, and stock were just

supplied with proper food in due proportions, then the animals would, other things being favourable, increase in weight, and take from their food the largest possible proportion of nutrients and store them up in their bodies.

CHAPTER XXX.

FOOD.

IN feeding it is wrong to attribute a higher value to one class of food constituents than another when they are equally essential. The albuminoids, the amyloids, and the fats being the nutrient components have been valued monetarily in the ratio of 12, 2, and 5 respectively—that is, fat occurring in food is considered for feeding purposes to have two and a half times the value of starch, and albumen six times the value.

Taking the value of starch as unity, then fat $= 1 \times 2\frac{1}{2} = 2\frac{1}{2}$ and albumen $= 1 \times 2\frac{1}{2} \times 2\frac{1}{2} = 6\frac{1}{4}$, otherwise fat is $2\frac{1}{2}$ times the value of starch, and albumen $2\frac{1}{2}$ that of fat. It would appear from certain experiments that have been made on the feeding of stock that to increase the live weight of an ox by 1 lb. the animal requires to be supplied with a quantity of food containing 2 lbs. of nitrogenous matter, 8 lbs. of carbohydrates including fat, and $\frac{9}{10}$ lb. of mineral matter, the

remainder being water and other substances of little or no nutrient value. To form this increase of 1 lb. in live weight the nitrogenous food supplies about .10 lb., the non-nitrogenous matters .6, and mineral substances .02, about $6\frac{1}{8}$ lbs. of the 11 being used up in respiration, the maintenance of animal heat, &c., and 4 lbs. to form manure, including about $\frac{4}{5}$ lb. of mineral matter. Only $\frac{1}{50}$ lb. of the $\frac{9}{10}$ lb. of mineral matter in food is assimilated in the animal body, about $\frac{40}{50}$ or $\frac{4}{5}$ going to the manure heap. Thus it will be seen that by passing crops through the bodies of animals 97 per cent. of the mineral matter of the food is returned to the soil in the form of farmyard manure, 3 per cent. being stored up in the animal body.

In the case of oxen and sheep 58 or 60 per cent. of the food is used for keeping up the temperature of the body and respiration, 33 to 36 per cent. forming manure, including about .7 per cent. of mineral matter, there being only from .15 to .2 per cent. of mineral matter retained in the body, together with from 5 to 7 per cent. of non-nitrogenous substance and .8 of nitrogenous matter. From 35 to 40 lbs. of turnips (swedes), 6 to 3 lbs. of clover, hay, or chaff, and 2 to 3 lbs. of oil cake will give an increase of one pound in the live weight of cattle. The ox assimilates about 6 and the sheep about 8 per cent. of the nutrient constituents of food supplied, while the pig stores up

about twice as much of the nitrogenous and non-nitrogenous nutrient constituents of the food as the sheep; the amount of mineral matter, .2 per cent., being the same in each case. The pig has been found to increase 1 lb. in live weight by digesting 5 lbs. of barley meal containing ½ lb. of nitrogenous matter, 3½ lbs. of non-nitrogenous matter and ⅑ lb. of mineral matter. Of the 5 lbs. 55 per cent. supports respiration and produces heat, fourteen forms manure and not more than 15 per cent. is assimilated, or 17.5 of the nutrient constituents of the food. The principal reason why the pig stores up such a large proportion of the food compared with the sheep and ox is chiefly due to the more concentrated form of its diet. In the above table, by taking the sum of the percentages of ash and water of each food from 100 we obtain the percentage of organic matter, and by deducting the percentage of albuminoids the percentage of non-nitrogenous substances is obtained; so that having the percentages of albuminoids and non-nitrogenous substances we can find from any given weight of food, by multiplying that weight by these percentages and dividing by 100, or pointing off two places, the weight of nitrogenous and non-nitrogenous matter in any food given in the above table, thus enabling us to diet stores economically, supplying to oxen and sheep nitrogenous and non-nitrogenous food in the ratio of about 4 to

25, and for swine in the ratio of 2 to 11, these proportions having been found to give good results. It has been found in fattening stores that roughly the percentage of fat becomes doubled, while the water, mineral, and nitrogenous matters become correspondingly diminished, as the following table will show :—

	Fat.	Nitrogenous matter. Lean.	Water.	Mineral matter.
Oxen, store	16	18	60.9	5.1
,, fat	33	15	50.5	4.5
Sheep, store	21	14.5	60.6	3.9
,, fat	39	12	45.75	3.25
,, very fat ...	53	9	35.1	2.9
Pig, store	25	14	58.3	2.7
,, fat	47	10.5	40.9	1.6
Calves, fat.........	17	16.5	62.2	4.3
Lambs, fat.........	37	10.7	48.8	3.5

An animal that is growing does not fatten so rapidly as one that has attained full size. As animals intended for the meat market are not allowed to arrive at maturity, the growing and fattening must go on simultaneously, and to effect this purpose they must be liberally supplied with nitrogenous matter, &c., to form bone and muscle as well as non-nitrogenous foods to form fat. Pigs and sheep are turned into pork or mutton before a year old, and bullocks are converted into beef when about three years, although they would grow if

allowed to live till six years old. In the case of cattle it is found that as their weight increases, the amount of nitrogenous food required is relatively less; thus a bullock requiring ¾ lb. per day of nitrogenous food when three months old will only require 1½ lbs. when two years old instead of 3½ lbs., as the animal increases in weight from 200 to 800 or 900 lbs. live weight, *i.e.*, cattle two years old require proportionately to their weight less than half the quantity of nitrogenous food as they do when three months old. The amount of carbohydrates or foods containing starch and sugar required is in proportion to the increase in weight, thus an animal a quarter old weighing 200 lbs., requiring 2½ lbs. of carbohydrates in food will require four times that amount when weighing 800 lbs. when two years old.

And roughly speaking the same quantity of fat should be supplied in food when a quarter and when two years old. These remarks also hold good to a certain extent when applied to growing sheep; thus a sheep eighteen months old requires a third less nitrogenous matter in food than when six months old, although the animal increases by one-half of its live weight in the meantime. The quantity of carbohydrates required at six months and eighteen months is the same in the case of the sheep, while only one half the fat is required when eighteen months old. Pigs increasing their live weight five times,

from 50 lbs. to 250 lbs., from three to twelve months old only require .6 lb. of nitrogenous matter in their food, just one-half more, instead of 2 lbs., five times the quantity; and of carbohydrates and fats they require 1½ lbs. at three months, and 4 lbs. at twelve months instead of 7½ lbs.

The ratio of albuminoids to carbohydrates, including fat, required in food in the case of cattle and sheep at three or four months old is as 1 : 5, and when two years old the ratio is as 1 : 8, the latter being the proportion found occurring generally in green fodder and roots, and the former in the cereals and meadow hay. Swine always require a more concentrated diet, the ratio of albuminoids to carbohydrates varying between 1 : 4 and 1 : 6½ from the wheat, rye, barley bran, and barley meal to rice meal and cereal seeds. Thus we see that the quantity of the food required by an animal at different periods of its growth varies, as well as the proportion in which the albuminoids and carbohydrates occur. An animal will require more heat-producing food in winter than in summer, and more in a cold country than in a warm one, and more when exposed to rain and cold than when properly housed. Horses, oxen, and other animals when hard-worked require three times the quantity of albuminoids and fats, and half as much more amyloids as when at rest.

In taking the percentage proportion of stomach and intestines to whole animal in the

case of the ox, the sheep, and the pig, it is found that they have $11\frac{1}{2}$, $7\frac{1}{2}$, and $1\frac{1}{3}$ per cent. respectively of stomach and $2\frac{3}{4}$, $3\frac{3}{5}$ and $6\frac{1}{5}$ of intestines, giving as a total of stomach and intestines, $14\frac{1}{4}$, $11\frac{1}{10}$, and $7\frac{1}{2}$ respectively. From these figures it will be seen that the ox is adapted for the digestion of bulky foods, especially those containing large quantities of cellulose and crude woody or vegetable fibre; the sheep is adapted for digesting less bulky food, and the pig is especially adapted for digesting the meal of the cereal grains, its digestive apparatus being unsuited for bran or bulky food of any kind. And in the feeding of stock attention must be paid to the nature of the digestive organs of the ox, the horse, the sheep, the pig, &c., in order that food best suited to be digested by these organs may be supplied to them. Cattle (oxen) are naturally supplied with large stomachs, in fact the ox is provided with a compound stomach, consisting of four cavities. The rumen, or *paunch*, is by far the largest of these cavities, and receives the food when first swallowed in an unmasticated crude state. It is merely a receptacle for storing it up until the animal has left off feeding. The food in this receptacle is somewhat moistened by a fluid secreted from its walls, and during rumination portions of it pass into the second stomach, termed the reticulum, or honeycomb, from the polygonal cells formed by its lining

membrane. From the honeycomb the food passes in pellets to the mouth to undergo a thorough mastication, from whence the pulpy food passes along the canal of the œsophagus without opening its lips, into the third stomach; but when food is swallowed without chewing it is in a rough and bulky condition, and opens the lips, passing into the first or second stomach. Water seems to pass into the second stomach. The third stomach is termed the psalterium, or omasum, or manyplies, from its internal foliated appearance. In this stomach the pulpy and soft food is spread over the mucous membrane, undergoing certain changes before passing onward into the fourth stomach, termed the abomasum or reed, where the process of digestion actually takes place, as this is the only stomach in which gastric juice is secreted, the other cavities, or stomachs, being merely preparatory to fit the food for digestion in the fourth cavity. Again, the intestinal canal is very long, so that, together with the large amount of stomach, oxen are especially adapted to digest grass, roots, and bulky food. Animals having a smaller amount of stomach are altogether incapable of digesting the bulky food on which oxen live. For instance, in proportion to the size of the animal, the stomach of the cow is eight times larger than that of the pig, so that swine are adapted for the digestion of a more concentrated food, like the meal of

the cereals. Since the price of butcher's meat has become so much higher than that of corn, relatively the feeding of stock has received much attention. Sixty years ago, cattle were four or five years old before they were sent fat to the butcher, but now the butcher gets them when about half that age. Lean cattle used to be sent from Scotland to England to fatten, but now this state of things has been reversed, for lean cattle are often sent from England and Ireland to fatten in Scotland. The fattening of cattle is effected by *grazing* or *stall feeding*. Very lean animals should not at once be put on rich pasturage, but should be fitted for it by being grazed on pasture gradually increasing in richness. The pasture land may be divided into three, four or five sections, and one section reserved until the most forward beasts are ready for it. The less favoured beast might be grazed on an inferior section as well as the dairy stock and the stores and sheep on a section still less luxuriant. By keeping one section free, and shifting the animals from one to the other, according to their condition and wants, a regular fattening rotation, so to speak, may be kept up. The pasturage of the country may be roughly divided into that occurring on the richest plains and valleys, and that on the uplands upon which grain crops cannot, from any cause, be profitably grown. The best of the pasturage may be used for fattening, that somewhat in-

ferior for dairy stock and for animals less forward in the fattening process, and the uplands for sheep or even stores. It is now a general practice to give additional food to fatten cattle even on the richest pasture, such as linseed cake, one of the most rapid fatteners. This cake is formed of the residue of the seed, after the oil has been extracted. It contains about 10 per cent. of oil and nearly 30 per cent. each of albuminoids and carbohydrates. Rape cake and cotton cake are also given.

Cake can be supplied to each beast at the rate of two or more pounds per day, in troughs in the field. Oats is also given for fattening grazing animals, and should be crushed. The cattle should have access to plenty of water, and rock-salt for them to lick. The animals during winter and spring are taken from the field and *stall-fed*, as rich pastures intended for fattening purposes should not be grazed during winter, so that they may be in a luxuriant condition for the cattle in spring. When taken from the field for the winter the cattle are fed on roots, oil cake, straw, hay, and corn. It is well to supply them at first with soft turnips for a fortnight, so as to prepare them for more nutritive food gradually. The roots should be given raw, and in slices to prevent choking. The roots are sometimes reduced to shreds by a pulping machine, and mixed with cut straw. Some cook or steam

roots before giving to cattle, but as roots are easily digested, and no useful purpose is effected by the process, it should be given up as labour lost. Cattle, when fattening, should receive three feeds of roots, corn, or cake in the morning, noon, and evening, and hay or straw every night. The oats should be crushed at the mill, or by an oat-crusher. Thus crushed oats may be mixed up with a mixture of roots and cut straw or hay; and oil cake, when broken fine, may be thus mixed with turnips, or given by itself. One pound of cake or corn, gradually increased to four, may be given per diem. No corn or cake is required at first, when fed on soft turnips. From 7 to 12 stones of roots should be given daily to each animal, according to its condition. However, it is usual to give them as much as they will eat. All changes in diet should be carefully and gradually made.

Besides grass, the natural food of sheep, it is not uncommon to give cracked beans or bruised oats when on pasture; hay is given to those to be kept as stock, and roots to those being fattened, but thousands of sheep never get anything but grass. During winter and spring sheep may be fattened on roots, and for this purpose about 20 lbs. per head per day is sufficient. The roots should be cut for fattening sheep, but not for stores. Hay may be given to fattening sheep in racks with a little bran, crushed corn, or cake broken fine. About ½ lb. of cake and 1 lb. of

oats will be ample. When on pasture sheep should have access to water and rock salt. The change from summer to winter keep should be very gradual. They should be first fed on white turnips, then on white and yellow, then yellow alone, then on a mixture of yellow and swedes, then swedes alone. In winter feeding they should be supplied with allowances of cake, chaff, and corn, say at seven in the morning, then two feeds of roots at intervals of two hours, then cake, chaff, and corn after another two hours ; after another interval cut roots and hay in racks at dusk.

Pigs only having one stomach instead of four like the ox and sheep require a more concentrated diet. Young pigs should be weaned gradually by allowing them to suck their dam once a day, and then withdrawn altogether, making up their food with buttermilk, boiled or steamed potatoes, cabbages and roots, to which they become accustomed before being wholly withdrawn from milk. At first, after weaning, they may be fed five or six times daily, but this should be reduced to three times, which is often enough. Besides the above foods Indian meal or ground grain as barley meal may be given alone to pigs. Pollard and bran are also given. Ordinary stores may be allowed to eat the refuse of the farmyard, the kitchen, dairy, garden, corn fields, &c., and when put on grass they should be ringed, and may be allowed plenty of cabbages, vetches, &c. When pigs are to be fattened they should

be kept in styes with yards attached, and should be provided with cereal meals and small or damaged potatoes, as this food lately is too dear to be given in quantity to pigs. Roots when steamed or boiled may be also given with a little bran, but bran should not be given in any quantity, as pigs cannot digest it properly. Bran, however, is an excellent food to prevent or cure weakness of bone in young animals, as it contains the mineral matters necessary to give strength of limb.

CHAPTER XXXI.

FOOD.

As we have seen above, all foods contain more or less albuminoids, more or less carbohydrates, including oils and fats, with saline or mineral matter, and water. And the great object in giving food to animals is to blend in the diet these constituents in that proportion required by each class of animal, according to its condition and the object of feeding. Above we have stated the kinds and quantities of food that should be given, and the proportion in which the nitrogenous and non-nitrogenous foods should be mixed. There are few foods that do not contain albuminoids to a greater or less extent, and still less that do not contain carbohydrates, in which most foods are particularly rich.

Animal life cannot exist without a supply of albuminoids, neither can it exist without carbohydrates, or the materials from which carbohydrates can be formed. In feeding an animal

on a particular kind of food alone, we run the risk of giving too much or too little nitrogenous food. The animal does not feel satisfied until it has had just sufficient of both these classes of food. If the food contains too little albuminoid matter, the animal must eat until it has taken sufficient albumen, and in doing so the chances are, with most kinds of food, that a large excess of carbohydrates or starchy food is taken, and extra and excessive work is thrown on the digestive organs to select the quantity of carbohydrates required from so large a mass of food. Again, extra work is thrown upon the excretory organs in throwing off and expelling from the body the surplus of useless food. Again, if a highly nitrogenous food is given to, or taken by, animals, an excess of albumen will be taken before sufficient non-nitrogenous or amyloid has been taken, so that additional work will be thrown upon the digestive and excretory organs in disposing of this extra supply of nitrogenous matter. If the food is taken in those proportions required by nature then the digestive and other organs will only be required to perform those functions for which they were designed, and good health will result, but by giving animals an excess of any one of the constituents of food an abnormal functional activity will take place, that will lead sooner or later to bad health of the animal. In fattening stock especially great care should be taken that

the food given does not require the digestive organs to perform more work than is necessary, since the extra work done will be abstracted from the amount of fat stored up or about to be stored up in the body of the animal.

Although more attention is paid to the feeding of stock and other farm animals than formerly, still the requirements of the animals are not sufficiently attended to. In many cases they are left when on pasture without access to a sufficient supply of water or rock salt. Now I consider the supply of rock salt very important, as it assists, although it may be taken in small quantities, in the digestive process, furnishing, as I have stated above, the chlorine to form hydrochloric acid, which, together with the pepsine of the gastric juice, form a digestive fluid, and the sodium is required for the bile. Food when taken into the mouth, if in a fluid state, does not require chewing, and does not require the admixture of the saliva. In fruits, for instance, the solid nutritious portion is minutely divided and intermixed with a large quantity of water, and in many artificially prepared foods there is a similar admixture of solid and fluid. Grass and roots, as may be seen from the preceding table, contain a large proportion of water. But many other foods are solid and dry, containing little water, and require to be well masticated in order to divide the solid and dry food minutely, and mix it with the saliva

secreted by the salivary glands, so that it may assume the consistency of fruits and other foods that do not require mastication. In mixing with the food as masticated, the saliva serves not only the same purpose as water, but it also, by the ptyaline or ferment that it contains, acts on the starch of the food, partially converting it into sugar. Thus the uses of saliva are partly mechanical and partly chemical. The quantity of saliva secreted by man has been estimated variously from 8 to 48 or even 70 ounces daily, but an average amount would be about 20 ounces containing about 20 grains of ptyaline. This saliva is continually being secreted, and when not spat out it is transferred to the stomach to aid in the process of digestion going on in that organ. It must be injurious to health to be continually spitting, like smokers especially. As soon as food is taken into the mouth, the saliva begins to flow more copiously and continues to flow during the process of mastication, and for some time afterwards it is secreted in larger quantities than usual, passing onward to the stomach in order to render its contents more fluid, and to assist in digestion. If there is not a sufficiency of fluid in the stomach a desire for drink will be felt, which should be gratified. The saliva has an alterative reaction during and immediately after eating, but the alkalinity diminishes and acidity increases the longer fasting is continued.

The food when transferred to the stomach by the act of deglutition is mixed with more water if not sufficiently diluted on entering that organ. The fat of food is divided into minute globules in the stomach, and is intermixed with the frothy fluid contents of the stomach, forming an emulsion. The fat is not subjected to any chemical change in the stomach. The conversion of the starch and other carbohydrates of the food into grape sugar, that was commenced in the mouth, is now continued in the stomach by the saliva that was intimately mixed with the boluses of food in the mouth, and by the continued addition of more saliva from the mouth other carbohydrates are changed into the soluble form, grape sugar, and even partially into lactic acid. And the albumen, gluten, caseine, fibrine, and other nitrogenous food, are converted into peptones that are soluble by means of a ferment termed pepsine, contained in the gastric juice, together with various acids contained in the stomach of animals. The pepsine cannot digest food by itself, neither can any of the acids, but their co-operation is requisite. The mucous membrane that lines the interior of the stomach contains little cavities, from the surfaces of which a fluid termed gastric juice flows out more abundantly after food has been taken. The lactic acid, that is formed by the continued action of the ptyaline upon the grape

sugar and other acids that may occur in the stomach, co-operates with the pepsine, converting nitrogenous foods into the soluble form, when they will pass through membranes and cell walls. Thus, by the action of the saliva, the gastric juice, and a uniform temperature of 36° or 37° C. the fat, the albumen or glutine, and the starch, with saline matter in the food are converted into a greyish pulpy mass, termed chyme, which leaves the stomach, passing through the pylorus and entering the duodenum, into which there is poured the bile and the pancreatic juice, which, together with the intestinal juice, mix with and change the chyme into chyle—a milk-white fluid. The fluid bile has had a great many functions attributed to it, but it doubtless disintegrates the fats, and moistens the villi of the intestine, which facilitates the absorption of the fatty substances. Some authorities state that the bile removes the acidity of the chyme, but this can only take place to a very slight degree, since the chyme is still acid in the intestine after the admixture, as the bile is often neutral and is never more than very slightly alkaline. The bile is an antiseptic fluid tending to prevent the fermentation and decomposition of the chyme. It is also generally considered to have a purgative action by stimulating the secretion of the intestinal walls. In man it would appear that there are about 5 lbs. of this fluid secreted

daily. The pancreatic juice is poured into the duodenum at the same point as the bile. This fluid contains an organic compound resembling ptyaline. This organic compound converts any starch that may be in the chyme into grape sugar. It also reduces the fats in the chyme into a more minute state of division, forming an emulsion and giving the chyme a milky appearance, when it is termed chyle. The intestinal juice secreted by the duodenum converts starch into sugar and emulsifies fats. The three fluids, viz. the pancreatic juice, the bile, and the intestinal juice, combine together to convert the chyme that leaves the stomach into chyle—a milky white fluid—ready to be taken up by the lacteals, and to pass onwards by the thoracic duct, in order to be emptied into the subclavian vein and thence forced forward to the lungs, where it is converted into blood. In man there are about 10 lbs. of pancreatic juice secreted daily, but in herbivorous animals (cattle) there is proportionately more. And there are about 10 ounces of the intestinal fluid secreted by man daily. A portion of the food in this is absorbed by the minute blood vessels spread over the whole of the internal surface of the stomach, and finds its way into the blood circulation without passing through the pylorus, duodenum, lacteals, thoracic duct, &c. This portion of the food almost immediately finds its way to the blood after being taken as food to recoup the exhausted

energies, long before the main bulk of the nutritious food passes into the blood circulation by the ordinary digestive routine. The food in its onward and downward transit through the intestines is continually receiving fresh increments of intestinal juices that effect certain changes upon it, rendering it more soluble, and better fitted to be taken up by the lacteals that cover them, ever extracting nutritive matter as the remnant of the food glides along, until nothing of nutritive value is left, and defæcation of the exhausted and indigestible constituents of the food is effected. The intestines in man are about seven times the length of the body, while in the sheep they are twenty-eight, and in the ox about forty-nine times the length of the body of the animal. Some further changes are effected in the chyle in its passage through the lacteals, and especially where they meet in knots or glands, and intermingle their contents. The lymph from the lymphatic vessels, abounding in the viscera, passes with the chyle into the lacteals, and is carried with it to the thoracic duct. The lymph, unlike the chyle, contains some of the waste materials of the body.

CHAPTER XXXII.

BREEDING.

THE breeding of animals is one of the most important and most arduous duties of the breeder, grazier, or farmer—requiring no ordinary amount of skill and judgment. More attention has been paid to the breeding of animals during the last century than had been altogether devoted to that object previously.

About 1760, Bakewell, the celebrated agriculturist, turned his attention to the breeding of sheep, cattle, and horses, but as he did not commit his principles to writing little is known about his system. However, we know that he was very successful, and produced a breed of sheep superior to any then or even now existing. It is probable that he crossed the bony, long, thin, flat-sided sheep of Leicester in the first instance, and afterwards resorted to breeding in and in, and a very careful selection of parents, producing an animal that matures at two instead of three years, having

little offal, small bones, a symmetrical form, shorter wool than the original animal, and fattening on the smallest amount of food. He received fabulous sums for his rams. He also introduced the valuable breed of longhorn cattle, and was almost equally successful in horse breeding, which he made very profitable to himself.

Again, the brothers Robert and Charles Colling improved the ordinary cattle of Durham by selection, crossing and breeding in and in, so that the offal and bone were reduced, and early maturity and symmetry of form effected. By their arduous and long-continued labours the value of this animal was increased from £8 or £9 to £150 in their own lifetime, and a few years ago a shorthorn bull and a shorthorn heifer were sold at upwards of £4,700 and £4,500 respectively. And in connection with other breeds of live stock the names of other individuals stand out prominently. By the exertions of these men the wealth of the country has been vastly increased, the weight of mutton alone having about doubled within the last forty years proportionate to the number of sheep kept. The weight of beef has also largely increased in proportion to the number of cattle, the same quantity of land sends a greater weight of meat to the market in a less time than formerly, so that the wealth of the country has been much increased. The principle upon

which this increase of wealth has been effected is that "like begets like," and the breeder has merely to form an ideal as to the form and qualities of an animal that will produce a desired result and then carefully select parents most nearly approaching his ideal, and by unflagging assiduity, crossing, and close breeding, attain his object. The protoplasm, the origin and basis of life, is the same for animals and plants, so that the eventual form assumed by it will depend upon the generating animals. The form internal and external of the animal producing the protoplasm is impressed upon it at or previous to the act of fecundation. The perfect form of the female impressed upon the protoplasm is modified to a greater or less extent by male impregnation, and is further developed in the womb or matrix of the female, or other depository of the fertilized ovum. Everyone may observe the resemblance between offspring and parents, and the *facsimile* that is sometimes produced. This reproduction according to model or pattern forms the basis of the breeding of animals. A skilled breeder can, by the selection of parents, produce animals of definite types; that is, animals possessing given qualities and specified forms. The form, the peculiarities, the disposition, and even the diseases of the parents, are transferred to the offspring, and even their descendants. The properties of any race or breed of animals may and do in breed-

ing become modified, and these modifications can be transmitted from generation to generation, if it is considered profitable or desirable to do so.

The climate, food, and general treatment of animals affect their covering, their shape, and even their habits and dispositions. Animals are bred according to the objects that the breeder desires to obtain. And the object or objects to be attained vary according to the kind of animal, and according to the qualities with which we wish to invest it. The horse is bred for fleetness, for strength, and for endurance, separately or collectively. Cattle are bred for beef or milk, or for both. Sheep are bred for mutton or wool, or both. Pigs are bred for the flesh alone, and poultry for the eggs, or flesh, or covering.

In the case of horses and cattle or sheep the objects to be attained are just the reverse.

With cattle and sheep the breeder endeavours to reduce the nervous system and render it subsidiary to the development of the stomach and digestive organs, whereas in the case of horses the stomach is rendered subservient to the chest, the brain, and the nerves, which are of paramount importance. The larger the chest the more air is respired, and the larger the quantity of blood purified, allowing the expenditure of more nervous energy, and producing more bottom or endurance. As we wish cattle to produce flesh or milk, and sheep

flesh or wool, and pigs flesh, we endeavour to reduce the nervous energy to a minimum, so that the flesh, milk, or wool may become a maximum.

In the case of the breed of cattle known by the name of the shorthorn we can obtain a maximum of flesh or milk from the same animal just as we please. If we want flesh the shorthorn will produce more than any other animal from the same quantity of food, and if we want milk the shorthorn will give more. The Leicester sheep will make more mutton from the same quantity of food than any other breed. And the Yorkshire pig makes much flesh from his food. In these animals the bones and the head have been made finer, the offal reduced, and the intensity of the nervous system minimized, while the valuable parts have been augmented so that the digestive organs convert the food taken into the greatest amount of fat and flesh. Otherwise these animals have, by successful breeding, become machines for the conversion of a minimum of food into a maximum of flesh.

Notwithstanding all that has been done lately in the improvement of breeds of live stock, there is still ample room for improvement in the figure of farm animals. If a good animal will from the same food produce, say only a seventh or an eighth, more flesh, how great would be the increase of wealth by

the replacement of millions of bad cattle by good ones. And although much has been done to increase the quantity of mutton, still much remains to be done in making the animals yield the greatest money return by converting the food into the greatest quantity of flesh, and especially on those parts of the animal's body where it is most valuable. We want more short legs, small heads, small bones, combined with a lymphatic temperament and early maturity. In dairy cows we want a greater development of the lactic system. Generally in horses we want more vigour and muscular activity, combined with weight, large bone, and quietness in cart horses, and with nervous energy, endurance, and lightness in the race-horse or thoroughbred. The thoroughbred, compared with the cart horse, is an unprofitable feeder, since a given quantity of hay or oats will make less flesh, but the nervous energy and muscular vigour will be much more. The thoroughbred will continue to exert himself when the cart horse will be exhausted, but the latter will thrive on a keep upon which the former will starve. The form and qualities of the offspring depend partly upon both parents, and it is essential that the qualities of both should be taken into account, for defects are more likely to be propagated in offspring than good qualities, and the affections and diseases of a parent may not appear in the first or

second generation, but in the second or third. There is, however, considerable difference of opinion as to the selective influence of sire and dam, some making out that the former and some that the latter is of most consequence. The Arabs appear to think that the selection of the mare is of supreme importance, while that of the horse is secondary.

We must conclude that the sire exercises a considerable influence upon the resultant offspring, for large horses and small mares produce large colts, and the offspring of a male ass and a mare greatly resembles the ass. Large bulls will produce larger calves. The cross between a Leicester ram and a Cotswold ewe will resemble the ram in fattening propensities and appearance. The Cotswold ram and Southdown ewe give a cross resembling the sire. The cross between the large-size Yorkshire pig and the small-size has produced the middle-size Yorkshire. If we put a coarse heavy mare with a thoroughbred an ill-assorted animal is the result, with coarse body and fine legs. If a large, coarse stallion is put with a well-bred, handsome mare, the offspring is larger than the dam but handsomer than the sire; the head is finer and the coarse features are much toned down. Thus the defects of one parent are modified and toned down by that of the other.

From the above and other considerations it would appear that the sire exercises a consi-

derable influence upon the size, the muscular power, and the general conformation, while the female influences the nervous system and the constitution, and is more likely to impart any hereditary disease or weakness to the offspring than the male. There are certain cases on record of a male animal with one female producing female offspring in every instance, while the same male, with another female, gave all male young. From this it would appear that the male influence predominates with some females and not with others. Again it would appear that the result varies as the copulation takes place at the commencement or termination of the heating. However further experiments are required.

The perfection of a breed may most readily be preserved by in and in breeding, but it has a tendency to perpetuate certain unfavourable predispositions and hereditary shortcomings, to which most breeds are liable. For instance, the marriage of near relations, such as cousins, tends to produce consumption, barrenness, insanity, &c., and doubtless lower animals are affected similarly, though to a less degree. No harm will follow if the male and female, from sire and dam, are put together if their organizations differ, but if they possess the same organization then evil results will follow; hence the care that is required in the selection of animals in close breeding. When a sire is

repeatedly put with his descending female offspring there is great danger that the animals produced will partake both the internal and external systems of the sire, probably weakened by the close union, and the reproductive faculties impaired. But in close breeding such near unions are not often resorted to, since the breeder has generally the choice of a second or third remove. Thus most of the evils attendant upon in and in breeding can be avoided by the careful selection of the animals, and a gradual weeding out of the bad ones.

The stud books will enable the farmer to purchase pedigreed mares, and these, when put with pedigreed horses, will secure an offspring that will be safe and satisfactory; but if any mare is used with a pedigreed stallion there is a risk. In rearing horses, the symmetry of form as well as the action has to be taken into account.

The breeding of cart is safer than that of race-horses, since it is not so liable to disease or bad habits. More attention is required in the selection of parents for the production of foals than in the case of cattle or sheep, because the farmer can dispose of a defective heifer or ewe to the butcher, but he is generally obliged to work and even breed from an ill-shaped and unpromising mare, thus perpetuating the bad qualities in the offspring, including diseases often acquired through hardship and labour.

The parents of the farm horse should be strong and healthy, in order that the foals may be so.

Crossing is the covering of a dam of one pure or no definite breed by the sire of another pure or no definite breed. Thus we are said to cross when we put a shorthorn bull with an Ayrshire cow, or an Ayrshire bull with a shorthorn cow; or again, when the shorthorn bull is put with common cows of no recognized breed. The Leicester and Cotswold, or the Leicester and Southdown yield a cross. The thoroughbred horse and the half-bred, or the half-bred and farm horse form a cross. The Berkshire or Yorkshire are used to cross with other breeds of pigs. A certain amount of skill is required in the crossing of animals, so that those possessing distinctly antagonistic qualities should not be put together, such as a thoroughbred and a cart horse producing an animal that is unsymmetrical, being too light for one purpose and too heavy for another. In the improvement of the breeds of horse those animals should be put together in which the dissimilarity is not quite glaring, as the cart horse with the half-bred, the half with the three-quarter, and the three-quarter with thorough. There is a danger in the pairing of cross-bred animals that some of the offspring may resemble the granddam and some the grandsire, instead of the immediate dam and sire, so that the beneficial qualities of the cross is not continued but a race of mongrels is the result.

In order to avoid this danger there must be a rigorous selection of those animals possessing the qualifications we desire to continue until the cross has become fixed and uniform. In this way many kinds of animals have been so much improved as to become almost new breeds; but crossing, unless some desired end is to be effected, is highly reprehensible, since a mongrel breed may be produced. With regard to sheep crossing is rather a necessity, for, on account of the scantiness of food and the severity of the weather, and other causes, we can improve the already existing animals by crossing without unfitting them for the native pastures; but with cattle all the advantages of crossing can be obtained in a great measure by using animals of the pure breed.

CHAPTER XXXIII.

STOCK.

By common consent the shorthorns are considered the best breed of cattle, inasmuch as they are the best feeders and milkers, and possess a considerable amount of adaptability to soils and climatic influences. However, there are many exceptional cases in which other breeds are preferable and more profitable. The shorthorns with the Ayrshire and Kerry give the largest yield of milk. For producing beef the shorthorn, the Hereford, the Devon, the Galloway, the West Highland, the Sussex, and the Angus are valuable breeds. As a general rule cattle feed on the plains and sheep on the hills, moors, and mountains, but where the soil is light and dry it is more profitable to allow sheep to consume the turnips upon the spot than to cart the food to cattle and cart their manure back again. Clayey land and the richer pastures are stocked by cattle, such as the clays of Somerset, Gloucester, Leicester,

Cheshire, Stafford, Derby, the marshes of Lincoln, Huntingdon, Bedford, Essex, the weald of Sussex, and the north of England, with the lowlands of Scotland, and a large portion of the soil of Ireland. The North and South Downs, the Cotswold, and other English hills, the moors, the heaths, and light and dry soils, and the Welsh, Scotch, and Irish mountains and moors are adapted for sheep. The long-woolled sheep are better suited for rich and low-lying land than other soils, while the short-woolled are fitted for higher and dry soils, such as the downs.

In good milkers the loins are wide and deep to the teats; the udder is large, well-developed, and elastic, inclining forward to the front of the hind quarters, with well-developed milk veins on the belly. Many dairymen also prefer narrow forequarters, for they consider that more milk will be secreted as these parts will require a less supply of nourishment than they would do if larger. The necks of good milkers are usually rather long.

By handling the skin or hide of cattle we can tell whether the animal is in good condition or not. If the skin is hard and thick, adhering closely to the body, the animal is a poor feeder, that is, it does not produce fat and flesh readily; but if the skin is loose and resilient, yielding to the slightest pressure, it shows that the animal is in good condition, and that the skin is well padded underneath with an abundant layer of

fat, and also that there is plenty of room for the further increase of the animal shown by its elasticity. The softness and mellowness of the skin is due to the excretions from the fat glands underneath it. The animal should be protected by a thick coat of hair, which should be soft to the touch. The tail should be fine and well covered with hair. The moisture on the skin of the noses of cattle and other stock denotes health and constitutional vigour.

The back should be pretty straight, the ribs should form almost a right angle with the spine, forming a broad back, and the space between the ribs and hips should be as small as possible, so that the body may not be too long in proportion to the breadth. A compact body fattens more readily and gives greater strength to the animal. The ribs springing well from the spine also gives roundness to the body, and allows more flesh to accumulate upon them than if the animal was more or less flat ribbed. This roundness of the body caused by the ribs also allows more space for the lungs and the liver—two most important organs ; the increased size of the former allowing an increased supply of blood to be aerated, and the larger the latter organ the more food will be digested.

The haunch should be muscular to the hock, and deep and long from the prominence of the haunch bone to the tail. The hind quarters

should be full, the legs being considerably apart and rather straight.

The neck should taper gradually to the breast, not being too short, and in the cow it should be finer and not so full as in the bull. The head should be small in proportion to the body, the forehead broad, and the horns fine and oily. The eye should be prominent, bright, and lively. The side view of a well-bred animal should be rectangular, with short legs below the knee and hock.

When cows are allowed sufficient of their natural food—grass—it has been found they will give the greatest quantity of milk. Roots may also be given with the grass or grains, keeping up the flow of milk, and cooked or mashed food, if given daily, increases the secretion of milk; but it is questionable whether the expense and trouble of cooking may not counterbalance any slight gain in this respect. An occasional salted mash is beneficial, and is much relished by cattle; besides, it is a change, and cattle, like human beings, benefit by change of food. There is no doubt but that by judicious feeding the quantity of milk might be very much increased and in many cases doubled.

Some feed milk cows on cake, beans, crushed oats, and other costly foods, but it is well to consider whether more milk may not be obtained at less expense. Furze is chopped up fine in many districts and given to cows, increasing

the quantity of the milk, besides heightening its quality. It is a mistake to feed animals too often, as they are rendered restless, and cannot sufficiently ruminate or digest their food. Six or eight meals daily disturbs cattle too much, and three or four meals would be sufficient. When house-fed in the winter, three feeds of roots, with hay or straw between, may be given.

Wild sheep are generally covered with short wool and long and straight hair, which, from its roughness, has the property of felting. When domesticated the long hairs disappear, and there is an increase of the length of the wool. In hot countries the sheep loses its fleece, which increases as the climate becomes colder. The serrations on wool are produced by microscopic scales overlapping each other, producing a saw-like appearance, so that one filament of wool interlocks with another. The quality of the wool varies with the soil, climate, food, shelter, and also with the breed of sheep producing it.

There is also great room for improvement in the breeding and rearing of pigs, as in the case of cattle and sheep. With proper attention the quantity of pigs' flesh might be doubled from the same quantity of food that is now given. This increase of flesh would render the keeping of pigs more profitable than it now is, so that more pigs would be reared and the wealth of the country from this source much increased.

And peasants, unable to keep cattle or sheep, would be enabled to increase their small income to a greater extent than they do at present. To insure this increase of value more attention should be given to the breeding of swine, so that the good points may be produced and bad points eliminated. The boar should be of a pure breed, possessing those good points; and the sow should be cylindrical in form, with a large belly capable of containing about a dozen young, and allowing them to suck her, and the body should be of a moderate length. If the sow is not prolific she should be disposed of, unless she possesses some other compensating quality. It is also desirable to get rid of sows that eat their young, or are not good nursers.

In the pig many of the points are the same as in the case of the sheep or the ox. The ribs of the pig should be well arched, or spring from the spine at right angles, forming a broad back that is almost straight and covered with flesh. The shoulders should be broad, the breast deep and wide, the bones fine, and the legs short. The neck should be short, and swell out from behind the ears, and join the shoulders wide and deep. The snout and face should be short, the mouth and the head small, the forehead concave and narrow, and the cheeks full. The hair should be long and fine, the skin thin and elastic, and the colour either white or black.

Surely the breeding, rearing, and feeding of pigs should or might be made profitable when we consider that we import upwards of nine millions sterling worth of pig's flesh yearly.

There is much room for improvement in the breeding, feeding, and rearing of all farm stock, including poultry, which is sadly neglected, as the importation of about three millions sterling worth of eggs, poultry, and game will testify. The value of the eggs and poultry produced in this country might be easily doubled, and with a little more trouble quadrupled, increasing the farmer's profit upon poultry without diminishing any other source of revenue. In the rearing of poultry the farmer possesses peculiar advantages over other people, for he can in a great measure feed poultry by refuse food that otherwise would be wasted, and when the birds are allowed to roam on the farm, or a portion of it, they can in a great measure feed themselves. They should be allowed plenty of lime—that from old walls will do. At any rate, the farmer should be able to keep fowl at 1½d. per head per week, ducks at ½d. more, and geese at double the cost of the latter. And by utilizing the eggs of fowls, and rearing chickens, a profit of 8s. per head of fowl should be made annually. This profit might be increased still further by keeping ducks, turkeys, and geese. On a farm of 200 acres from £40 to £50 yearly might be made by keeping poultry, and on 100 acres half

that amount without much trouble, but if more attention was paid to this matter of course the profit would be larger. Nearly 800 millions of eggs are imported annually at a cost of 2½ millions sterling, allowing ample scope for the production of eggs in this country. On the Continent the rule is, that every house keeps poultry, whereas in England the keeping of poultry is exceptional. In some parts of the country, especially on small farms, poultry is extensively kept, but the large farmer too often considers the keeping of poultry beneath his notice, and also regards them as a nuisance in his fields. This large objection may be overcome by confining them. And when purity of breed is to be considered, the various kinds of poultry should not be allowed to intermix promiscuously. In the north of France and Germany especially poultry is kept on a large scale, and is one of the objects if not the primary object of farming.

The common ailments of live stock are in a great measure due to the neglect of the most common rules of health. Thus rat tails in horses and cattle is caused by constant exposure of the fee and legs to the cold wet earth or mud. Tetanus is caused by rain falling upon animals through a bad roof, by exposure to the cold, or by a blow on the head or spine. Cancer of horses' feet is generally caused by bad treatment, bad ventilation, and filthy housing.

Thrush in horses is caused by wet pastures, the water softening the hoofs, rendering them more porous, and if the water contains an alkali in solution the complaint is much more intensified; and foot-rot among sheep is caused by the continued exposure of the feet to the wet. Sheep and cattle are affected by splenic apoplexy when kept on low-lying land that is badly drained.

Exposure to cold and sudden chills causes sore throat in horses, and sometimes produces surfeit when accompanied with food too rich or too abundant after scarcity. Stinge in cattle is also due to an abundance of rich food after hard fare, and so is braxy in sheep to a considerable extent. An excess of food is also the principal cause of black quarter in young cattle. And colic, a horse complaint, is caused by allowing the animal an excess of food: grain and dry chaff, with an extra quantity of water after a long fast, so that the beast is swollen out, sometimes ending fatally. Cattle suffer from a complaint termed hoove, by taking a large feed of roots or grass, or a moderate feed of wet food. This disease, sometimes ending fatally, may be prevented by cutting the grass nine or ten hours before giving it to the animal. Diarrhœa is produced by impure water, impure air, or bad food. Impure water is also a fruitful source of various other complaints. Cows acquire pulmonary disease by overcrowding in towns.

In the country the most healthy soils are the granite, metamorphic, and trap rocks, the clay slate, the oolitic limestone, the chalk and sandstones. When the sandstone and chalk are mixed with clay the soil is rendered damp and unhealthy. Alluvial clay, dense marly, and magnesian limestone soils are usually unhealthy.

With proper care the health of vigorous animals may be maintained without resort to cordials, balls, and other messes. And it is far less trouble to keep the stock free from disease han to cure them when the complaint has been acquired. As the health of stock is dependent upon the same laws as the health of human beings, it is therefore necessary that the stable, the byres, and other houses for the accommodation of stock should be capacious, well ventilated, light and airy, dry, and well drained underneath. The inside should be kept scrupulously clean and free from smell by sprinkling some disinfectant or gypsum on the floor daily. Then with proper and punctual feeding, in which change, if desirable, must be effected gradually, and precautions taken against exposure to cold, and also to the baneful influences of wet feet, or any other cause that would be likely to result unfavourably, the farmer will be enabled to maintain his stock in good health, and save himself a deal of trouble in physicking for complaints that might with ordinary care have been prevented. Let the farmer

be as careful of the health of his stock as he is of his own, and if he is fortunate enough to possess healthy and vigorous animals, he may, with due care, maintain them in good condition without resorting to physic. Too often animals are treated as machines, and no thought or care is taken of them until something attracts attention, and then medicine is resorted to. Animals are often kept too long without food and drink, after which they eat to excess, entailing the complaints mentioned above. They are often worked into a violent perspiration and afterwards allowed to stand till they become chilled. They are exposed to sudden changes of temperature without any thought, and also to wet feet, reckless of the danger until too late. And animals often do not get a handful of salt with their food, and in the field there is often no rock salt for them to lick. Let a knowledge of the unchanging laws of health be disseminated, and let farmers practise the healthy treating, housing, and feeding of their stock, and they will benefit not only themselves but the nation generally.

CHAPTER XXXIV.

CATTLE.

THE shorthorns, by common consent, take the first place among the English breeds of cattle, since they possess nearly all the good points of the others, without their defects. They have been named from their horns, which are short, rather flat, and curled semicircularly. This breed grows and fattens rapidly, milks well, and transmits with certainty its own good points to other breeds with which it may be crossed. They are hardy animals, having constitutions that suit most climates and soils. They have a docile and quiet disposition that is favourable to fattening, and the flesh is so evenly distributed over the frame of these animals that the form of a parallelogram is apparent. Their skin is soft to the touch, being covered with fine hair that is red or white, or both, and sometimes these colours are blended, forming a roan. They have a short neck, a broad and straight back continued to the tail, which hangs square from

the body. They have fine limbs, straight and short; the under line between is almost level, and the udder is large in advance, with square hanging teats. The ribs are roundly arched from the backbone, giving a deep and capacious chest. They have a handsome head and a full, bright eye. This breed is not only held in the highest estimation in the United Kingdom, but also in the Colonies, America, and other civilized countries.

The Ayrshires, so-called from the county, are common in the neighbouring and other parts of Scotland as well as in England, Ireland, and other countries. They, probably, furnish the best dairy cows, as the yield of milk is not only very large but the quality is good. An Ayrshire cow will often give upwards of 900 gallons annually, or an average of 10 quarts daily. They are a hardy race, capable of bearing almost any variation in the climate and of subsisting on the medium pasture of the hilly districts; yet a richer or a rich pasture and a milder and less humid atmosphere will suit them equally as well, if not better. This race is rather small, but when crossed with the shorthorn the size is increased, the cross attaining an early maturity, being but slightly inferior to the pure breed. The hind-quarters are broad and deep, which is a good feature in milch cows, but the fore end is narrow and light, which is a bad feature for fattening purposes.

The neck is straight with the back, and the horns are wide apart on the skull, curving upwards. The legs are short and the bones small. The colour is sometimes brown or red, and sometimes black and white, but the usual colour is red, spotted with white.

The Herefords are much inferior to the shorthorns in milking qualities, but almost equal them in maturing and in the formation of beef which is much prized, being mottled, fat and lean. They are of a dark red colour, with a white streak along the back, white bellies and faces, and the white hairs are sometimes distributed among the red, producing a roan colour. The mottled-faced animals are, probably, the best in form. The narrow hocks and prominent buttocks, however, detract somewhat from the symmetry of this breed. Their hair is soft, long, curly, and glossy. They are square and bulky; anteriorly the chest is very capacious, being enclosed by well-rounded ribs. The offal is light, the legs being short and bones small. The horns are of a medium size, wide set, and turned upwards. This breed originated in the county after which it is called, where it is still the prevailing race, and in the neighbouring counties it is very common, as well as in other parts of England and some parts of Ireland and Scotland, as well as in the Colonies, America, and other countries. As the production of meat has been the chief object of the breeders,

the milk has been neglected, the calves being allowed to run with their dams. However this breed is kept on many dairy farms in the West of England, where they will do well on pastures not rich enough for shorthorns. This breed, when crossed with others, increases their fattening propensities.

The Devons are a fine race of cattle, easily known from all others by their shape and colour. Their frame is cylindrical, the chest wide, the ears small and short, and they are stout and heavy in proportion to their height. Altogether they are beautiful, symmetrical in form, and their hind parts are long and their shoulders are obliquely set, favouring their facility in stepping. They are of a fine, dark-red colour, except on the scrotum and udder, which are white. Their hardy constitution adapts them especially to the cold, poor uplands of their native county, but they will thrive well on most soils and in most climates. They are the best breed of cattle for draught; they are excellent feeders, fattening well, their beef commanding the highest prices; but their yield of milk, though small, gives a very rich cream, which is much celebrated.

The Norfolk and Suffolk polls are a hornless breed, derived by crossing the native Suffolk polled cattle with the Galloways that were formerly grazed in the eastern counties. They are also distinguished by their red colour, with white udder. They have a constitution that is capable

of withstanding the severe winters and springs of the eastern counties. They are undoubtedly good milkers, and their beef is very fine.

The Galloways are a black, hornless breed by selection, hailing from the south-west of Scotland, being sent in large numbers to the eastern English counties for grazing, as their flesh is excellent in quality. They are not adapted for dairy farms, as their yield of milk is small in proportion to the size of the animal. The head is capped with a knob covered with a hair tuft, the back is straight, and the legs short but strong. They are often crossed with the shorthorn, and sometimes with the Ayrshire, the produce being an improvement.

The West Highland breed occupy the district from which they derive their name, especially Argyleshire and the Hebrides. They produce meat of excellent quality, and are in great demand for grazing. Their hardiness enables them to brave the moist and stormy Highland climate. The quantity of milk they yield is small, but the quality is good. This breed is rather small, the body is broad, deep, compact, and symmetrical, and the legs are muscular but short. The skin is thick and clothed with glossy and shaggy hair, which is brown, brindled, grey or black. They have long, white upright horns, widely set apart on a short head covered with curly hair, overhanging their prominent and piercing eyes.

The Kerry is the only breed of cattle peculiar to Ireland. It is a small, handsome animal, hardy and adapted to subsist upon mountainous pasturage. The Kerry yields a large quantity of milk, being equal to that of any other breed in proportion to size. The milk is rich, producing good butter, and the flesh is in great demand. The usual colour is black with white streaks along the back and belly, but they are sometimes black and white, or brown. The skin is soft and mellow, and the horns are fine, with the points turned upwards. This breed is well adapted to the hilly districts of its native county, and Clare, Galway, Mayo, and Donegal, on the west coast, and Antrim, Down, and Wicklow on the east coast of Ireland.

The Sussex bear a close resemblance to the Devons, but they have larger bones, heads, and horns. The colour is the same. They were formerly, like the Devons, used as draught animals instead of horses, but now considerable attention is paid to the improvement of this breed, which is common in Kent and Surrey. They are hardy and arrive at an early maturity, producing good meat even on poor pasture, but they are bad milkers.

The longhorns, so called from the horns which are very long, curving downwards often under the jaw and sometimes touching the cheek. The back is straight, the framework long, and the hips broad in the cows, which are

good milkers. This breed is of a deep red colour, pied and brindled, with a white streak along the back. They were formerly much appreciated, but now few herds are kept; however, it is still to be seen in parts of Warwick, Leicester, and Derby. It crosses well with other breeds, having produced many of the present cross-bred milk cows in various parts of the country. The celebrated Robert Bakewell improved this, the earliest, breed.

The Jerseys, so called after one of the Channel Islands, are valuable for their milking qualities. They have deer-like heads and slender-built frames, that are light in front and heavier behind, like the Ayrshires. They are of a fawn or silver grey colour, and the hair is sleek and short.

The Guernseys, so called from the sister island, is a coarser animal, and has a longer carcass than the Jersey. They are not quite so good milking animals as the Jerseys, but are somewhat better flesh formers. They are generally red and white in colour, with white noses.

The polled Angus and the polled Aberdeens are sometimes considered as two breeds, but generally the Angus includes both; they are usually black, rarely brindled or red, and sometimes pied white. They much resemble the Galloways with their tufted heads, but the hair is shorter, and the frame is larger. They are hardy, coming early to maturity, and produce

good beef. The cross with the shorthorn is a good converter of food into flesh. This breed is principally confined to the north-east of Scotland, especially in Aberdeen, Kincardine, and Forfar.

The runts, derived from the black Welsh mountain bullock called a runt, are abundant in the grazing districts of Wales. They are hardy and can be bought cheaply for grazing, and produce good beef. They do not exhibit the symmetry of form of other breeds, being narrow in proportion to their height, but lately some attempts have been made to improve the Welsh cattle. The horns are widely set apart, curving upwards. The Pembrokes, Glamorgan, and Anglesea breeds of Welsh cattle somewhat resemble the West Highland, but they give more milk.

The Shetland is not much larger than the calves of many of the other breeds. It is very hardy, and is a good flesh former upon scanty pasturage. The beef is fine, and the milk is abundant in proportion to the size.

CHAPTER XXXV.

SHEEP.

THE Leicester generally takes the first place for the production of meat and wool. It is rectangular in form, with a broad and deep chest, full shoulders and square rump, with deep hind-quarters. The back is straight, and the well-arched ribs render it broad. The head is small and hornless, and the neck tapering. The bone is small, and the offal light. They yield about 7 lbs. of white wool, and are brought to market when about fifteen months, weighing about 25 lbs. per quarter. They require good pasture and shelter. They are used in improving other breeds, by crossing.

The Cotswolds, so called after the hills in Somerset, have been modified and improved by crossing with the Leicesters, from which they may be distinguished by their larger body, and a tuft of wool on the forehead. They grow very rapidly, weighing 20 lbs. per qr. at ten, and 30 lbs. at fifteen months. The chest is wide

and full, the back broad, and the thighs and hind-quarters well developed. Unlike the Leicester, they will subsist on coarse pastures in exposed situations, and they yield a heavy white fleece.

The Southdowns, so-called from the Sussex Downs, take the first place among the English short-woolled sheep. The body is cylindrical, the back broad and straight, the hips and the chest wide. The rump is broad and long, the legs are of medium length and speckled, and the bone fine. The head is hornless and of a brownish grey colour; and altogether the form is very symmetrical. The wool is very fine, close, white, and curly, weighing about 3 lbs. They are good flesh formers, coming early to maturity, and their mutton (20 lbs. per quarter) at fifteen months, fetches the best price in the market. They are hardy animals, capable of enduring the droughts of summer and the cold, bleak winter winds with a scanty supply of food, and they thrive well in Norfolk, Cambridge, Essex, and other English counties, the south of Scotland, and parts of Ireland. When crossed with long-woolled sheep they produce a large animal yielding good mutton. Every ten ewes give about twelve or thirteen lambs.

The Cheviots, so called from the hills to the north of England, are the best breed of mountain sheep we have. The chest is full, the fore-quarters are somewhat light, but the hind-

quarters are deep and well developed. However, altogether their form is good. The legs are of medium length, clean, white, and fine; the head is also clean and white, and there are no horns or wool on the forehead, but the neck and the remainder of the body is well covered with soft, thick wool, used to make the soft yarn for Scotch Tweeds, the fleece averaging upwards of 3½ lbs. Their mutton is very good, and the average weight is 16 or 17 lbs. per quarter. They are very hardy animals, capable of bearing the coldest and stormiest weather, and living on the poorest fare; and they are especially adapted for the hills of North England, Scotland, and parts of Ireland. They cross well with other breeds, especially with the Leicester, giving an animal that is suitable for large districts of moderately elevated land in the United Kingdom. They are prolific, but owing to the climate it is scarcely possible to rear more than one lamb to the ewe.

The Shropshire have only lately obtained popularity beyond their native county, but now they are the favourites in the Midland counties, and other parts of England, Scotland, and Ireland. They resemble the Southdowns in form, but are larger, yielding longer wool (6 lbs. a fleece), fine and close, and fine mutton. The legs and faces are of a dark grey colour, and they are hornless. They are hardy animals, can subsist on moderate keep, and come to maturity about the same

time as the Southdowns. The ewes are prolific and are good mothers.

The Lincolns have lately been much improved in form by crossing and careful breeding. They are exported to the colonies and other parts of the world as they are very valuable for crossing. They have now good symmetry, coming early to maturity, producing fine mutton. Having an excellent constitution, they can thrive on wet clayey soils. Their wool is more lustrous, coarser, and longer than that of the Leicester.

The Wiltshire Downs have, by crossing and careful breeding, been much improved latterly, and have been reduced to a definite type. They resemble the Southdowns, but their carcass is heavier. Their mutton is very good, but their fleece, though of average quality and weight, is inferior to that of the Southdowns. They are hardy animals, and can bear the exposure, wet and cold, of Hants, Wilts, Dorset, Gloucester, Oxon, and Bucks. They are prolific, and valuable for crossing.

The Romney Marsh or Kentish has been much improved by crossing with other breeds, but the form requires further development, as the original sharp shoulder has not been altogether effaced. They give a heavy fleece that is fine and valuable for spinning. They are small compared with many other breeds, and mature early.

The blackfaced sheep of Scotland are especially adapted to the mountains and wild moors of that country. They are very hardy and can live on rough and scanty food, such as coarse herbage and heath. Their fleece (3 lbs.) is coarse and of medium length, and only suitable for the coarsest manufactures, but their flesh is esteemed for its venison flavour. They are a horned race, the horns being spirally twisted, and the males are larger than the females. The legs as well as the face are black, and there is a tuft of wool between the horns of a light hue. They cross with the Leicester, produce good mutton, and come to early maturity.

The Welsh sheep subsist on the herbage found on the highest parts of the mountains of their native country. The fine flavour of Welsh mutton is doubtless due to the various aromatic herbs which are eaten with the scanty grass. They are very long in the hind quarters, and are slenderly built, suiting them for a mountain life. The face and legs are black, and the fleece is black, grey, or brown. Their soft wool makes the celebrated Welsh flannel, and their mutton is excellent. They are active, not bearing restraint, prolific and good mothers, and the males have horns.

The Radnor is the name applied to the hill sheep of that county, Montgomery, and Brecon. This breed has many of the characteristics of the Welsh sheep. They are hardy, prolific, and

are frequently crossed with the Leicester and Shropshire to produce fat lambs.

The Roscommon is the name applied to an Irish breed, the result of a cross between the Old Connaught and the Leicester. The wool is soft, and the mutton good. This breed matures early, and is fed on grass and hay.

The Oxfords possess a combination of the characters of the Cotswolds, the Wilts, and the Sussex Downs. They are dark in colour, legs included, and there is a knot of wool on the forehead. The wool grows thick, hard, and coarse. They mature early, and are prolific. They are specially adapted to subsist on the green crops of cultivated land.

The Border Leicesters are doubtless a cross between the Cheviot and Leicester. Their mutton is rather coarse, with much fat. Their fleece, when kept on sheltered, rich land, is excellent. They mature early, and can subsist on scanty supplies of food.

The Dorsets are a tall and light breed, with long legs, white faces, and horns. They are the favourite breed in their native county, Wiltshire, and other counties. They are prolific, often lambing twice a year, producing lamb mutton for Christmas. Their mutton is good, and so is their wool, but the fleece is light and short. The Wiltshire fine cloths are manufactured from their wool.

The Exmoors have been much improved lately. They are compactly built and short,

with short legs, white fleeces, legs, and faces, with horns curving outwards and downwards. Their fleece is long, and their mutton is very good.

The Dartmoors are like the Exmoor in many respects. They are small, with white legs and faces, and soft wool. They are late in maturing, but their mutton is very much esteemed.

The Somersets are bigger animals than the Dorsets, and their wool is longer and quite as fine. They are a prolific and active breed.

The Devons are a hornless breed, with white faces. They are found in their native county, Cornwall, and Somerset. They are a larger breed than the Leicester, which has been used to improve them.

The Ryelands are a hornless breed, with a tuft on the forehead, and white faces. The fleece is small, but of good quality. They are found in Hereford and Monmouth.

The Limestones are found in the common and limestone heaths of Westmoreland. The horns of the males are larger than those of the females. Their legs and faces are white. Their mutton is very good, and their fleece is longer than that of the Leicester. They are prolific, sometimes have three young, and hardy, but do not succeed on wet land.

The Lonks are found in the North of England. They have curled horns, and streaked black and white legs and faces. However, they are not much patronized.

CHAPTER XXXVI.

HORSES, PIGS, AND POULTRY.

IN the English race-horse the brain and nerves are more highly developed than in other horses, and as the chest is deeper and more capacious, more blood is purified and more nervous energy expended. The general form of the race-horse is beautiful and full of symmetry, the proportions of the various parts being exquisitely balanced to give the necessary strength, speed, and bottom, or endurance. The general colour is bay, chestnut, or brown, with a few streaks of white. The average height is about 15 or 16 hands. It is generally agreed that this breed has been produced by crossing the Arab with the native English horses. The valuable points in the race-horse now are elegance of form and fleetness for short distances, combined with early maturity, rather than size, strength, and bottom.

The cart-horse is about 16 hands high, having a large massive frame, large bony legs, the feet

well covered with hair, a strong neck, and a moderately large head. It is very strong, capable of drawing heavy loads or ploughing stiff clay soils, and good tempered and hardy.

The Clydesdale, the most valuable breed of farm horses, derives its name from the valley of the Clyde, where it has been produced, either by crossing the native Scotch mares with Flemish stallions, or by close attention to the selection and breeding the native farm horses. The legs are bony, strong, muscular, heavy, and of moderate length; sometimes rather long. The hind-quarters are broad, the girth deep, the shoulders obliquely set, and the head proportioned to his body, which is often not so strong in proportion to the legs. The average height is upwards of 16 hands, and the colour is brown, black, or grey, with white markings on the face, forehead, or legs. These horses have strong constitutions, good tempers, and, al- hough their legs are heavy, they walk fast, with long strides.

The Suffolk is a most useful horse for agricultural purposes. It is not so high as the Clydesdale, averaging upwards of 15 hands. The legs are not so heavy, and there is less hair on them and the pasterns. The Suffolk has a round body, deep at the girth, the ribs being well arched, and the hind- and forequarters well developed. The neck is gracefully curved, and he has a fine head. This

horse is a steady draught animal, with a good temper, taking long and nimble strides.

There are also various cross-bred and half-bred horses with ponies. The coach-horse is a cross between a light draught horse and a thoroughbred, but many carriage-horses are now almost thoroughbred, being about 16 hands high. The hack is a three-quarters or a half-bred horse about 15 hands high, having sound feet and good legs, being used for riding. Trotting roadsters and cobs have stouter body and limbs than the hack, and more of the draught horse than the thoroughbred in their build.

Ponies are small horses, from 9 to 13 hands high. The Shetland pony is upwards of 9 hands, the Welsh upwards of 11 hands, and the Exmoor upwards of 12 hands high. They are generally well formed, hardy, nimble, and strong in proportion to their size.

PIGS.

Berkshires are well shaped, excepting that the hind-quarters droop a little; the ears project, the heads are of a medium length, and they are thickly covered with hair, being of a hardy constitution. The colour is black or dark-brown and white, the tip of the tail, feet, and nose being white. This breed is above the medium size, but the legs are short. The bacon is of very good quality, the fat and lean being well dis-

tributed. This breed is used for improving Irish and other breeds by crossing.

The Yorkshire breed is white, and is large, middle, or small size. The large variety have long and narrow bodies, long heads, and drooping ears. They mature late; are of a large size when full grown; they are cured for large hams and bacon.

The small Yorkshires have a compact, stout, and symmetrical form, but they cannot stand much exposure. The bone is fine, the back straight, the shoulders broad and full, and the skin is generally covered with long curly hair. The ears project forwards, and the nose is turned up and short. They mature early, fattening readily, and when crossed with other varieties an improvement is effected.

The middle Yorkshires are the result of a cross between the large and small varieties. They derive their fattening propensities from the small, and their hardiness from the large varieties. They are prolific and good nurses.

The Dorset breed is black and handsome, with little hair. The legs are short, so are the noses, and the ears incline forwards. These pigs are symmetrical in form, and fatten rapidly.

The Suffolks are also a black breed, of good form, with turned-up noses and ears, straight back, and firm shoulders. In form they resemble a parallelogram. Their constitution is good, and their skin is covered with soft long hair.

The Essex breed is also black, resembling the Dorset, excepting that the nose is straighter, and the head longer. These pigs are of good form, and fatten very rapidly.

The Irish swine are black or white, or both colours, and spotted. They are a large breed, with coarse bones, long hair, and large ears. They have been much improved by crossing with the Berkshire and other English breeds.

The Tamworths are a red, profitable, and hardy breed.

POULTRY.

The Dorkings have a short neck, a large breast, and a plump form. Their legs are short and white, with five toes. They are the white and coloured varieties having a full rose. The hens lay large white eggs, and are good setters, but the chickens are delicate and cannot bear a damp soil or much exposure. Their flesh is white, and of excellent quality.

The Cochins, of which there are four varieties, are of large size, but of clumsy form. They are all hardy birds, excellent layers, and good mothers. When allowed free range they will pretty well obtain sufficient food. They weigh 9 or 10 lbs. when full grown.

The Hamburg fowls have fine, red, double combs, taper blue legs, large tails, and a body of moderate size. They lay nearly the whole year round, but their eggs are rather small.

They are small feeders, and, if allowed to roam, will find most of their food.

The Spanish fowls are usually black, with white faces. The hens lay very large eggs, but do not care for sitting. Their flesh is very white.

The Polands are distinguished by the large, round tuft on the head, and by their beautifully neat and compact form. They are of medium size, and are good layers.

The French fowls, such as the Houdans, Crêve-Cœurs, and Le Mans, are hardy, plump birds, good layers, and their flesh is much esteemed.

The Plymouth Rocks, Leghorns, and Andalusians are profitable fowls.

The English Game is a graceful, majestic, and beautiful bird. The purity of this breed is well preserved. It is used for improving other breeds. The hens are not good layers, but the flesh has a fine flavour, though it is yellow and unsuited for boiling.

The turkey was introduced into Europe and this country from North America, its native place. It is the largest of our poultry. The average weight of a cock turkey is about 12 lbs., but they sometimes more than double this weight. The bill is curved and short, and the upper part is covered with a fleshy carbuncle, sometimes pendulous and sometimes erect. The head is bare, and a tuft of hair hangs from

the anterior portion of the lower part of the neck of the male. The tail is broad, and can be erected and spread out when the bird desires to assume his stately and proud strut. The plumage is beautiful. In this country it rears one brood yearly. The young require much attention for a few weeks, being very tender, but they are hardy enough afterwards. The eggs are large and the flesh is excellent. They will subsist upon grain, chopped nettles, bran, insects, frogs, boiled potatoes, &c.

The duck is a valuable bird of which there are many varieties, but the two most common and useful are the Aylesbury and the Rouen. The Aylesbury is of a pure white colour, and is very hardy, being capable of bearing a hot or cold climate. They are very prolific, and weigh, when eight weeks old, about 4 lbs., at a year old about 7 lbs., and sometimes nearly 10 lbs. The female lays for upwards of three months, yielding from forty to eighty eggs. They hatch their eggs in about four weeks, and should be allowed plenty of straw to cover the eggs when the hatcher leaves the nest for a short time. The young should not be allowed to enter the water for about ten days. The legs of the Aylesbury are of a dark yellow, and their broad and long bill is flesh-coloured.

The Rouen resembles the wild duck, being dark coloured, and without a rival for beauty of

plumage. This variety is as hardy as the Aylesbury, and is of equal weight. The Pekins and Cayugas rival the Aylesbury in general utility. The East Indians are small, and more ornamental than profitable.

Geese are valuable birds, and if allowed to roam over the fields or waste they will require little, if any, extra food; on this account they have been termed the farmyard scavengers. In fact, unless they have a good run it is better not to keep them, as they require plenty of grass and grain. At four months old a goose will cost 2s. or 2s. 6d., and with an expenditure of 1s. for oats, and a run where they have plenty of green food and refuse, a fat goose worth 7s. may be produced at a cost of about one-half that amount. The legs of the goose are more forward than those of the duck; hence they are better walkers, and spend more of their time on the land. They are bulky birds, sometimes weighing as much as 10 lbs. The female occasionally rears two broods of ten in the season, which are ready for the table in about three months; besides the flesh the quills and soft feathers are valuable. It is most profitable to rear geese when they have free access to water.

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